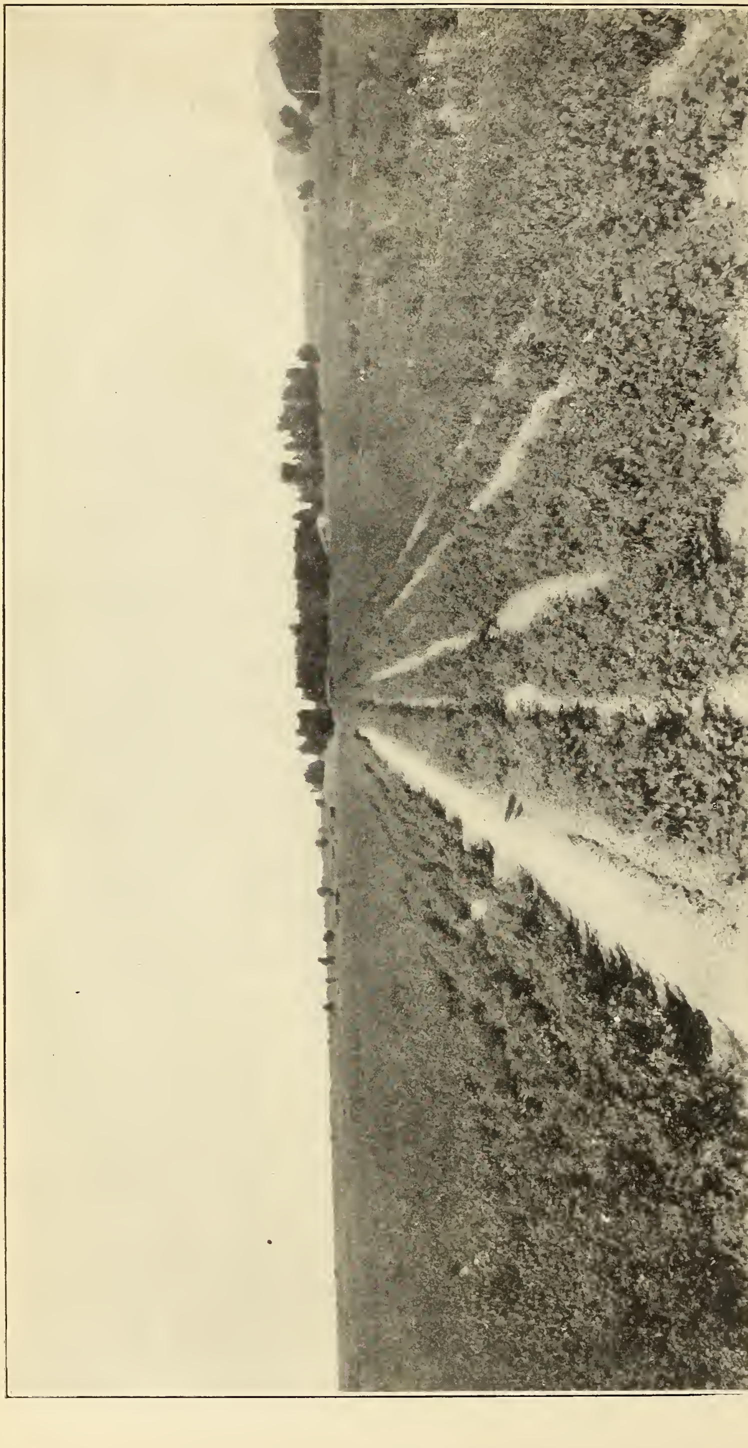


EXPERIMENTAL COTTON FIELD AT YUMA, ARIZ., IN 1907.

U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 128.
B. T. GALLOWAY, *Chief of Bureau.*

EGYPTIAN COTTON IN THE SOUTHWESTERN UNITED STATES.

BY

THOMAS H. KEARNEY,
PHYSIOLOGIST IN CHARGE OF ALKALI AND DROUGHT RESISTANT PLANT BREEDING INVESTIGATIONS,

AND

WILLIAM A. PETERSON,
FARM SUPERINTENDENT, WESTERN AGRICULTURAL EXTENSION INVESTIGATIONS.

ISSUED JUNE 13, 1908.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1908.

BUREAU OF PLANT INDUSTRY.

Physiologist and Pathologist, and Chief of Bureau, Beverly T. Galloway.
Physiologist and Pathologist, and Assistant Chief of Bureau, Albert F. Woods.
Laboratory of Plant Pathology, Erwin F. Smith, Pathologist in Charge.
Investigations of Diseases of Fruits, Merton B. Waite, Pathologist in Charge.
Laboratory of Forest Pathology, Haven Metcalf, Pathologist in Charge.
Cotton and Truck Diseases and Plant Disease Survey, William A. Orton, Pathologist in Charge.
Plant Life History Investigations, Walter T. Swingle, Physiologist in Charge.
Cotton Breeding Investigations, Archibald D. Shamel and Daniel N. Shoemaker, Physiologists in Charge.
Tobacco Investigations, Archibald D. Shamel, Wightman W. Garner, and Ernest H. Mathewson, in Charge.
Corn Investigations, Charles P. Hartley, Physiologist in Charge.
Alkali and Drought Resistant Plant Breeding Investigations, Thomas H. Kearney, Physiologist in Charge.
Soil Bacteriology and Water Purification Investigations, Karl F. Kellerman, Physiologist in Charge.
Bionomic Investigations of Tropical and Subtropical Plants, Orator F. Cook, Bionomist in Charge.
Drug and Poisonous Plant Investigations and Tea Culture Investigations, Rodney H. True, Physiologist in Charge.
Physical Laboratory, Lyman J. Briggs, Physicist in Charge.
Crop Technology and Fiber Plant Investigations, Nathan A. Cobb, Crop Technologist in Charge.
Taxonomic and Range Investigations, Frederick V. Coville, Botanist in Charge.
Farm Management Investigations, William J. Spillman, Agriculturist in Charge.
Grain Investigations, Mark Alfred Carleton, Cerealist in Charge.
Arlington Experimental Farm, Lee C. Corbett, Horticulturist in Charge.
Vegetable Testing Gardens, William W. Tracy, sr., Superintendent.
Sugar-Beet Investigations, Charles O. Townsend, Pathologist in Charge.
Western Agricultural Extension Investigations, Carl S. Scofield, Agriculturist in Charge.
Dry-Land Agriculture Investigations, E. Channing Chilcott, Agriculturist in Charge.
Pomological Collections, Gustavus B. Brackett, Pomologist in Charge.
Field Investigations in Pomology, William A. Taylor and G. Harold Powell, Pomologists in Charge.
Experimental Gardens and Grounds, Edward M. Byrnes, Superintendent.
Foreign Seed and Plant Introduction, David Fairchild, Agricultural Explorer in Charge.
Forage Crop Investigations, Charles V. Piper, Agrostologist in Charge.
Seed Laboratory, Edgar Brown, Botanist in Charge.
Grain Standardization, John D. Shanahan, Crop Technologist in Charge.
Subtropical Laboratory and Garden, Miami, Fla., Ernst A. Bessey, Pathologist in Charge.
Plant Introduction Garden, Chico, Cal., August Mayer, Expert in Charge.
South Texas Garden, Brownsville, Tex., Edward C. Green, Pomologist in Charge.
Farmers' Cooperative Demonstrative Work, Seaman A. Knapp, Special Agent in Charge.
Seed Distribution (Directed by Chief of Bureau), Lisle Morrison, Assistant in General Charge.

Editor, J. E. Rockwell.
Chief Clerk, James E. Jones.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., March 25, 1908.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 128 of the series of this Bureau the accompanying manuscript, entitled "Egyptian Cotton in the Southwestern United States," by Thomas H. Kearney, Physiologist in Charge of Alkali and Drought Resistant Plant Breeding Investigations, and William A. Peterson, Farm Superintendent, Western Agricultural Extension Investigations.

This bulletin calls attention to the fact that we now import from Egypt an average of sixty million pounds of cotton annually, notwithstanding the fact that this country far surpasses all others in its exports of this staple. The Bureau of Plant Industry has experimented for several years past with a view to establishing Egyptian cotton culture in some portion of the United States. In the main cotton belt the results on the whole have not been encouraging, but in the irrigated districts of the extreme Southwest, notably in southern Arizona and southeastern California, much progress has been made in acclimatizing two of the leading varieties and improving them by selection.

The climatic and soil conditions of the Colorado River region are admirably adapted to cotton growing and considerable interest in this crop has recently been manifested there. Owing, however, to the distance from manufacturing centers and the high price of labor which prevails, it is believed that a profitable cotton industry can be developed in that region only by associating it with some special type of cotton bringing a higher price than Middling Upland and not grown elsewhere in the United States. Egyptian cotton fully meets these requirements.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

PLATES.

TEXT FIGURES.

EGYPTIAN COTTON IN THE SOUTHWESTERN UNITED STATES.

INTRODUCTION.

Although the United States is by far the greatest cotton-producing country in the world, a large quantity of this staple is every year imported from Egypt. During the past ten years the direct imports from Egypt have averaged nearly fifty-four million pounds, besides an average annual importation from Great Britain of eight and one-half million pounds, the great bulk of which was undoubtedly produced in Egypt. In 1907 the value of the direct imports from Egypt exceeded all records, amounting to over $16,000,000. The average price of this cotton on the Boston market in 1907 was 21.9 cents per pound.

Several varieties of cotton are grown in Egypt, but all of them are of one well-marked type that resembles in many respects the American Sea Island. They are characterized by long and very strong fiber, smooth seeds, small, pointed, three-locked bolls, and yellow flowers. Some of them, notably the Abbasi and Jannovitch varieties, are second only to Sea Island cottons in the length, fineness, and silkiness of their fiber. The first is pure white, the latter of a very light cream color. The most extensively grown variety, Mit Afifi, has a soft, rather crinkly fiber of a characteristic light brown color that renders it especially useful for certain classes of cotton goods in which the natural color of the fiber is retained. The great strength and high degree of twist allow the production of a very strong yarn. The best Egyptian cottons bring a price second only to that paid for the highest grades of Sea Island, being used solely in the manufacture of the finest goods. They are especially suitable for mercerizing, taking this process better than either Sea Island or Upland cottons, and are largely used for mixing with silk and for the manufacture of cloths in which a high finish and luster are required.

In view of the considerable value of this import, the Department of Agriculture is endeavoring to develop Egyptian cotton culture in the United States in order to supply our own market with a home-grown product. The Office of Seed and Plant Introduction has several times imported seed of the standard Egyptian varieties and these have been tested at many localities throughout the main cotton belt from South Carolina to Texas, as well as in extreme western Texas, New Mexico, Arizona, and southeastern California.

In the humid part of the United States, where cotton is already the principal crop, the Egyptian types have given only indifferent success, although the quality of the fiber produced has in many cases been excellent. The chief drawback has been their late ripening, and hence the failure to obtain full yields.

Success in this effort can be looked for in the Southwest, and especially in the Colorado River region, where the very long, hot, almost rainless summers, deep alluvial soils, and irrigated agriculture approximate the conditions obtaining in Egypt. The length of the season in southern Arizona and southeastern California permits many more bolls to ripen on plants of the Egyptian varieties and hence larger yields than anywhere in the cotton belt proper.

That success could be expected in the Southwest had already been indicated by the results obtained at Phoenix, Ariz., in 1900 and 1901 by the Territorial Experiment Station. In 1902 the Bureau of Plant Industry commenced experiments with Egyptian varieties at Barstow, Tex., and Carlsbad, N. Mex. (both localities in the Pecos Valley), and at Yuma, Ariz., and Calexico, Cal., the latter two localities being in the Colorado River region. For various reasons the work was finally concentrated at Yuma.

During the first three years the results were far from encouraging, so far at least as the Mit Afifi variety is concerned. The plants made an exceedingly rank growth, were relatively sterile, the bolls opened very late and imperfectly, and the fiber was relatively short and coarse. After five years of acclimatization and selection, however, there has been a very great improvement in all these respects. In 1907 Mit Afifi cotton yielded at Yuma at the rate of 990 pounds of fiber to the acre, a yield practically equal to that of the most productive Upland variety that was grown in the same field. The fiber averaged nearly 1½ inches long, was exceedingly strong, and possessed the delicate brown color that is so desirable in this type. The bolls, although much smaller than those of Upland varieties, opened perfectly. It was found that the cost of picking was only about one and one-half times as much for Egyptian cotton as for such large-bolled Upland varieties as Triumph and Rogers Big Boll.

In view of these results, the possibility of establishing Egyptian cotton culture on a commercial scale in the irrigated valleys of the Southwest deserves serious consideration. The remoteness from existing markets and the scarcity and cost of labor make it very doubtful whether short-staple Upland varieties can be profitably grown in that part of the country unless the unusually high prices of the last few years are maintained. On the other hand, the more valuable long-staple Upland or "Peeler" varieties have not yet yielded at Yuma as heavily as the acclimatized Egyptians. The best prospect of building up a permanently remunerative cotton industry in

the Southwest undoubtedly lies in identifying that region with the production of a special type of high-grade cotton, one that is grown in no other part of the United States and is demanded by a special market willing to pay high prices for a first-class product. All these requirements are met by Egyptian cotton and by no other.

The climatic conditions of the Colorado River region in southern Arizona and southeastern California are unrivaled from the standpoint of cotton growing. At least 600,000 acres of excellent land are or soon will be under ditch in the Imperial, Yuma, Salt, and Gila valleys. One-fifth of this acreage could produce the average amount of Egyptian cotton that is annually imported into the United States. The soils are for the most part very fertile and an abundant and permanent supply of water for irrigation is at hand. It has been demonstrated that yields of one to two bales per acre are possible in this region and the fiber produced has been pronounced by experts as equal to the better grades imported from Egypt.

Two principal difficulties remain to be overcome: Labor and marketing. Since cotton must be picked by hand, the first is a serious difficulty in a region where labor is so scarce and high priced. The problem of transportation also remains to be solved. But, in view of the high price brought by this cotton, there is good reason to believe that it will be found feasible to ship it by rail to Pacific coast or even to Gulf ports, and thence by water to the New England cities where it is manufactured. So long as these problems remain unsolved, however, farmers who are contemplating growing cotton in the Southwest are cautioned to look carefully into the possibilities of picking and marketing their crop before planting any considerable acreage.

Since there is every indication that Egyptian varieties offer the best prospect of building up a profitable and lasting cotton industry in the irrigated valleys of the Southwest, planters in that region are urged to consider the question carefully before committing themselves to growing Upland varieties. The introduction of the latter would seriously interfere with keeping the Egyptian varieties up to the high standard which has been attained, since a certain amount of crossing would inevitably take place. Moreover, Indians and other pickers, should they become accustomed to the large-bolled Upland varieties, would be more reluctant to pick the small Egyptian bolls than if they were familiar only with the latter. Finally, there would be danger of introducing with the seed of Upland varieties some of the diseases and insect enemies that ravage this crop in the Southern States, but have not yet appeared in the isolated valleys of the Southwest.

The introduction of the cotton boll weevil would be ruinous to the industry at the very outset. Immunity from this destructive insect can be insured only by a rigorous inspection of all cotton seed intro-

duced from the weevil-infested district, which now includes practically the whole of Texas, as well as parts of Louisiana, Mississippi, Arkansas, and Oklahoma. The safest plan would be to admit no seed from other cotton-growing districts that has not been thoroughly fumigated.[a]

Those who contemplate experimenting with Egyptian varieties of cotton should avoid the use of directly imported seed, which is likely to give disappointing results during the first two or three years it is grown in the United States and hence to prejudice the grower against this type of cotton. Thoroughly acclimatized seed is under all circumstances to be preferred.

Since cotton growing under irrigation in an arid climate is still in the experimental stage in the United States, it has been deemed advisable to begin this paper with a brief description of the physical conditions prevailing, the varieties grown, and the cultural methods used in Egypt, where the crop is produced under irrigation with great success on a large scale. The portion of the United States that most resembles Egypt in its physical characteristics will then be taken up and the principal features of its climate, soils, and water supply will be pointed out. The results so far obtained in adapting Egyptian cottons to this area by acclimatization and breeding will next be discussed. Experiments in methods of growing the crop under irrigation are described and such recommendations as to cultural practices are given as the information now at hand will warrant.

COTTON CULTURE IN EGYPT.[b]

No country in the world is better adapted than Egypt to growing cotton. The long, hot, rainless summers, deep alluvial soils, plentiful supply of water for irrigation, abundance of cheap labor, facilities for economical transportation to the best markets, and, last but not least, the possession of distinct and very valuable types of cotton are a combination of conditions for the production of this staple that is well-nigh unrivaled. Hence it is that cotton can be grown at a profit in the Nile Delta on land that sells for from $300 to $800 an acre.

---

[a] Farmers' Bulletin 209 gives full particulars regarding the fumigation of cotton seed.

[b] The following description is based partly on the results of an expedition to Egypt made for the Office of Seed and Plant Introduction in 1902 by Messrs. T. H. Kearney, of the Bureau of Plant Industry, and T. H. Means, formerly of the Bureau of Soils, now of the United States Reclamation Service, the primary object of which was to study the cotton industry of the country and the climatic and soil conditions under which it exists. Published accounts of Egyptian agriculture have also been freely consulted. In regard to the varieties grown and the cultural methods used, much information has been drawn from Mr. G. P. Foaden's Notes on Egyptian Agriculture, published as Bulletin 62 of the Bureau of Plant Industry, U. S. Department of Agriculture, 1904, to which the reader is referred for further details.

Agricultural Egypt consists of the long narrow valley and the broad fan-shaped delta of the River Nile. In the Nile Valley south of Cairo about 2,300,000 acres are in crops, while in the Delta, where nine-tenths of the cotton is produced, there are 3,400,000 acres of cultivated land. All of this land is under irrigation, the rainfall being wholly inadequate for crop production. An elaborate system of canals carries the water of the river to every part of the cultivated area. The recent completion of two great dams on the Nile in Upper Egypt, one for storage and the other for diversion, in addition to the diversion dam that has stood for many years at the point where the river forks, a few miles north of Cairo, insures a sufficient supply of water to irrigate practically this entire acreage, even in years when the river is lowest.

While other summer crops, such as rice, Indian corn, and, in southern Egypt, sugar cane and sorghum, are extensively grown, cotton is by far the most important money crop of the country and is in fact the backbone of Egyptian agriculture. It is estimated that this crop now occupies annually from one and one-half to one and three-fourths million acres. The fertility of the soil is in large part maintained by the almost universal practice of growing in winter leguminous forage crops, the most important of which is berseem, or Alexandrian clover.[a] Cotton is grown once every two or three years in rotations which include clover or beans and wheat or barley as winter crops and Indian corn as a late summer crop.

PHYSICAL CHARACTERISTICS OF THE COUNTRY.

CLIMATE.[b]

Egypt is essentially a great oasis in the midst of the most extensive body of extremely arid land in the world. West of the Nile and beginning almost at the river bank the Sahara stretches across northern Africa to the Atlantic Ocean. From the east bank of the river,

[a] For a description of this plant and the important part it plays in Egyptian agriculture, see Bulletin No. 23 of the Bureau of Plant Industry, 1902; also Bulletin No. 62 of the same series, pp. 46–49.

[b] The meteorological data for Egyptian localities are taken from Capt. H. G. Lyons' "Physiography of the Nile River and Its Basin," Cairo, 1906, pp. 296 to 298 and 339 to 341. The length of the periods covered by the observations is not stated. The data for Phoenix and Yuma, Ariz., have been obtained from Prof. A. J. Henry's "Climatology of the United States," Bulletin Q, U. S. Weather Bureau, 1906, pp. 907 and 909. The observations of temperature and humidity at Phoenix cover a period of eight years. Those of temperature at Yuma cover a period of twenty-eight years and those of humidity one of fifteen years. It should be noted that the observations are taken at Phoenix at a height of 47 feet above the ground and at Yuma at a height of 16 feet (5 feet during the first ten years), a difference that should probably be taken into account in comparing the records from the two stations.

interrupted only by the narrow Red Sea, the desert extends to northwestern India. Consequently, except in the district near the Mediterranean Sea, Egypt has an arid climate. In southern Egypt especially the air is very dry and the rainfall is exceedingly light, the annual average, even at Cairo, being only 1 inch. In the Delta region, which borders on the Mediterranean, the rainfall is greater, averaging 8.26 inches at Alexandria, on the coast. The mean relative humidity, especially in the months from March to August, is also considerably greater in that part of the country.

As regards temperature, Egypt possesses a subtropical climate, the greater part of the country being nearly frost-free. The winters are short and mild, the summers very long and hot. These are excellent conditions for the varieties of cotton grown in Egypt, which require an unusually long season in order to ripen their entire crop.

The following table affords a comparison of the temperatures of Egypt with those of the southwestern portion of the United States:

TABLE I.—*Mean monthly and annual temperatures, in degrees Fahrenheit, at localities in Egypt and in the southwestern United States.*[a]

Month.	Alexandria, Egypt.			Cairo, Egypt.			Phoenix, Ariz.			Yuma, Ariz.		
	Mean.	Mean of maximum.	Mean of minimum.	Mean.	Mean of maximum.	Mean of minimum.	Mean.	Mean of maximum.	Mean of minimum.	Mean.	Mean of maximum.	Mean of minimum.
	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
January	57	64	51	54	65	44	52	65	39	54	66	42
February	60	70	53	57	70	47	56	68	41	59	72	46
March	63	70	55	62	75	50	60	73	46	64	78	50
April	66	74	59	70	83	55	67	82	52	70	85	55
May	71	79	64	77	91	61	75	90	60	77	93	61
June	76	82	69	82	95	65	85	101	69	85	101	68
July	79	85	73	83	97	69	90	104	77	92	106	77
August	80	86	74	83	95	69	89	102	76	91	104	77
September	79	85	72	78	90	66	83	97	69	84	100	70
October	75	82	69	74	86	63	71	86	56	73	87	58
November	68	75	61	66	76	54	61	75	46	62	76	49
December	61	68	54	59	68	48	52	66	38	56	68	44
Year	70	77	63	70	83	58	70	84	56	72	86	58

[a] The Delta of the Nile, in which the bulk of the Egyptian cotton crop is produced, lies between Cairo and Alexandria. Meteorological data are wanting for localities in the Delta itself, but the conditions are probably intermediate between those at Alexandria and at Cairo. Of the two localities in the southwestern United States for which data are given, Phoenix represents the Salt River Valley and Yuma the valley of the Colorado River. For the third important area which is believed to be well adapted to the culture of Egyptian varieties of cotton, i. e., the Imperial Valley, in southeastern California, the available records are not sufficient to serve as a basis for comparison.

Alexandria, on the Mediterranean coast of Egypt, has a less extreme climate than Cairo, which lies at the apex of the Delta of the Nile and almost touches the desert. The variation from season to season in mean temperatures and in the means of the maxima and minima is much smaller at Alexandria than at Cairo. Even at Cairo, however, the summers are decidedly cooler and the winters are somewhat warmer than at Phoenix and Yuma. The yearly means and means of the maximum and minimum temperatures are much alike at all four localities.

The table following shows the mean relative humidity of Alexandria and Cairo, Egypt, as compared with points in Arizona:

TABLE II.—*Mean relative humidity in percentages of saturation at localities in Egypt and in the southwestern United States.*

Month.	Alexandria, Egypt.[a]	Cairo, Egypt.[a]	Phoenix, Ariz.[b]	Yuma, Ariz.[b]
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
January	64	72	50	50
February	62	70	45	49
March	61	61	38	46
April	60	54	31	39
May	60	50	26	40
June	64	53	22	39
July	67	61	35	48
August	64	67	39	52
September	63	68	38	49
October	64	72	38	49
November	61	72	44	47
December	66	74	44	51
Year	63	64	38	46

[a] One observation made at 8 to 9 a. m., daily.
[b] Mean of two daily observations, at 5 a. m. and 5 p. m.

The above table is inserted because the humidity of the atmosphere at different localities is usually compared on the basis of percentages of possible saturation at the temperature prevailing when the observations are made; but there is reason to believe that the factor that vitally affects the growth of plants is the saturation deficit, i. e., the difference in weight between the amount of water vapor actually present in a given volume of the atmosphere and that required to saturate it at the mean temperature for the period under consideration. Hence the following table is likewise presented:

TABLE III.—*Mean saturation deficit (weight in grains of the additional water vapor required to saturate a cubic foot of air) at localities in Egypt and in the southwestern United States.*

Month.	Alexandria. Egypt.	Cairo, Egypt.	Phoenix, Ariz.	Yuma, Ariz.
	Grains.	*Grains.*	*Grains.*	*Grains.*
January	1.9	1.3	2.3	2.4
February	2.2	1.6	3.0	2.9
March	2.4	2.4	3.7	3.7
April	2.8	3.7	5.2	5.2
May	3.3	4.9	7.1	6.3
June	3.4	5.4	10.4	8.4
July	3.5	4.9	10.1	8.9
August	3.9	4.0	9.2	7.9
September	3.9	3.3	8.0	6.6
October	3.3	2.4	5.4	5.2
November	2.9	2.0	3.6	3.2
December	2.0	1.4	2.6	2.4
Year	3.0	2.9	5.2	4.6

During the summer months the saturation deficit is considerably greater at Cairo than at Alexandria, while in autumn and winter it is greater at Alexandria than at Cairo. At both Egyptian localities the saturation deficit throughout the year is much lower than at Phoenix and at Yuma, Ariz.

A curve representing the variation in the saturation deficit of the air from month to month throughout the year would be much the same for Alexandria and for Cairo. At both localities there is a rather gradual increase from the minimum in January to the maximum (which occurs in August and September at Alexandria, in June at Cairo), followed by a gradual decrease to the January minimum. A curve representing the variations from month to month at Phoenix and at Yuma would be on the whole similar, June to September being the months of maximum saturation deficit at these localities.

A characteristic feature of the early fall months in the Nile Delta are the heavy fogs, which often persist until 9 or 10 o'clock in the morning. This is a feature that is absent from the climate of the southwestern United States. When accompanied by excessive heat these fogs are said to cause premature dropping of the cotton bolls.

SOILS.

Egypt, to quote a familiar saying, is "the gift of the Nile." This is true in a double sense, since not only does the life of that nearly rainless country depend upon the water supplied by the river, but its agricultural soils are all of alluvial origin, being the accumulated sediment of countless Nile floods. As in the case of most alluvial soils, those of Egypt vary greatly in mechanical composition, according to the distance from existing or ancient stream channels at which they were laid down. Especially in the Delta region, clay loams and clays greatly predominate over other soils, but silt loams, loams, and sandy loams also occupy extensive areas, and near the edges of the desert almost pure sands occur. The clays and clay loams are mostly black in color and doubtless contain considerable organic matter. These soils, when dry, are apt to bake on the surface, thus giving up much moisture by evaporation, and to form deep cracks through which a great deal of water is lost by percolation. To prevent this the surface must be kept well mulched. All these soils are usually of a considerable depth, which is said to average 40 to 60 feet.[a]

[a] In his "Physiography of the River Nile and Its Basin" (Cairo, 1906, p. 339), Capt. H. G. Lyons gives the thickness of the sediment, as determined by eighteen borings made in various parts of the Delta and Valley of the Nile, as far south as Luxor. The average thickness, as shown by these borings, is 43½ feet.

The heavier soils are preferred for cotton culture in Egypt, as they are more retentive of moisture and lose their plant-food components less readily by leaching when irrigated. The silt loams, which have these properties in a high degree and are at the same time much less difficult to work than the clay loams and clays, are probably the most valuable of Egyptian soils. On the average, cotton is grown on much heavier land than in the United States. On the light soils in Egypt both yield and quality of fiber are said to be inferior.

In point of soil fertility it is found that when an exhaustive crop like cotton is grown for any length of time the supply of nitrogen soon becomes insufficient and ultimately fertilizers containing phosphoric acid are also found beneficial. Potash seems to be almost always present in adequate amount.

Under the ancient irrigation system of Egypt, which consisted in turning the water of the Nile during its annual flood into a series of extensive basins, no diminution in soil fertility was observed. Under this system no other irrigation was ordinarily given and only one crop was grown annually, wheat or barley being alternated with beans or clover. The nitrogen furnished by the leguminous crop, together with the small percentage of this element contained in the heavy deposits of sediment [a] left in the basins after flooding, amply sufficed for the needs of the cereal crop. Nowadays the conditions are very different, since irrigations are given at frequent intervals, much more leaching takes place, less sediment is deposited, and cotton is extensively grown. Cotton is an exhaustive crop, especially under Egyptian conditions, since the seed, which contains about one-third of the nitrogen taken up by the cotton plant, is exported to Europe, with the exception of the small percentage that is required for planting.

As far as possible leguminous crops are grown in rotation, but even these fail to supply all the nitrogen required by the cotton plant, and the remainder must be obtained from other sources. The chief nitrogenous fertilizers available are barnyard manure and the débris of old villages, which contains nitrogen equivalent to 2 or 3 per cent of nitrate of soda. The supply of these materials is much smaller than the demand, however, and the need of commercial fertilizers is becoming every day more apparent.

Alkali resistance of the cotton plant.—In various parts of Egypt, especially in the northern part of the country, near the Mediter-

[a] The Nile when highest carries in suspension at Cairo about 160 parts of solid matter per 100,000. This is a relatively small amount in comparison with that carried by the Colorado River at Yuma, Ariz., which averaged 700 parts per 100,000 throughout the year 1904. When we consider, however, that in Egypt the flood water stood in the basins for six weeks, depositing nearly all the material it held in suspension, we can infer that the total amount of sediment left behind was by no means insignificant.

ranean, alkali soils occupy extensive areas. Sodium chlorid (common salt) seems generally to constitute the bulk of the salts present. The reclamation of these soils by washing and drainage has been undertaken on a large scale, partly by the government and partly by private capital. Cotton, which is usually put in at the earliest possible moment on these "washed lands," has been shown by soil tests to be superior to most crop plants in its ability to withstand alkali. Near Alexandria a good stand of cotton was found by Means and Kearney to be growing where the first 2 feet of the soil contained 0.6 per cent of readily soluble salts, and occasional plants were able to withstand nearly 2 per cent.[a]

The presence of a moderate amount of salt in the soil is generally considered in Egypt as beneficial to cotton. It is said to check the tendency to excessive growth, to hasten ripening, and to improve the length, strength, and color of the fiber.[b] Even when considerably more than 1 per cent is present the strength of the fiber is said not to suffer greatly, although the length is impaired.

VARIETIES GROWN.

The varieties of cotton known as "Egyptian" are unquestionably of American origin. They belong to the same botanical species (*Gossypium barbadense*) as the Sea Island varieties or to a closely related species. Like the Sea Island varieties they have yellow flowers, small, pointed, three-locked bolls (Pl. IV), and smooth black seeds. The bolls are chiefly borne at the ends of long branches rather than close to the main stem, as in most Upland varieties. The Egyptian varieties, as is shown in Plates II and III, make larger plants than do most American Upland varieties. It is said that in 1818 Sea Island cotton was introduced into Egypt from Georgia by a French agriculturist named Jumel and that from this source the present Egyptian varieties are descended.[c] Other authorities consider Egyptian

[a] See T. H. Means, "Reclamation of Alkali Lands in Egypt," Bulletin No. 21 of the Bureau of Soils, U. S. Department of Agriculture. Also T. H. Kearney and T. H. Means, "Crops Used in the Reclamation of Alkali Lands in Egypt," Yearbook, U. S. Department of Agriculture for 1902, pp. 573 to 588 (especially pp. 586 and 587).

[b] Fertilizers containing phosphoric acid are said to produce the same effects and to counteract the excessive vegetative growth caused by too liberal application of nitrogenous manures.

[c] In all likelihood they have originated by mutation or discontinuous variation, a phenomenon which would be very apt to appear in such narrow-bred local varieties as the Sea Island when transported to an entirely new environment. The suddenness with which recently created Egyptian varieties have appeared and the obscurity attending their origin lend further probability to this view. The relative fixity of their characters during the first few years in which they are extensively grown argues against a hybrid origin, hybrids between different species of cotton being notoriously difficult to "fix."

cotton more nearly related to Peruvian cotton (*Gossypium peruvianum*), which was also formerly grown in Egypt.

While closely resembling each other in many of their characters and constituting a well-defined type, at least from an agricultural and commercial point of view, several well-marked varieties of cotton now exist in Egypt. At the present time the varieties that are chiefly grown are Ashmuni, Mit Afifi, Jannovitch, and Abbasi.

Ashmuni.—Ashmuni is the oldest of the four varieties and was formerly the most widely grown, although now largely supplanted by more valuable kinds. Its fiber is relatively short ($1\frac{1}{8}$ to $1\frac{1}{4}$ inches), and possesses neither the strength, fineness, nor luster of the Mit Afifi. In color it is pale brown. It ripens earlier than the other varieties and is considered to be the one that is best adapted to the hot, dry climate of southern Egypt, where alone it is now grown. It gives about 30 per cent of lint in ginning. Its average yield per acre is low compared with that of the other varieties, and its fiber sells for about one dollar less per hundred pounds.

Mit Afifi.[a]—In acreage and the total value of its product the Mit Afifi far exceeds all the other varieties. At least 70 per cent of the total Egyptian acreage in cotton is of this variety.[b]

Mit Afifi is the standard variety of the country, so much so that when Egyptian cotton is referred to, this variety is ordinarily meant. It is considered the hardiest variety grown in the country and the one that is surest to give a good yield of high-grade fiber under a great diversity of conditions. Mit Afifi was brought into cultivation about thirty years ago, and is said to have originated from a variety, now little grown, known as Gallini, which was itself of American Sea Island origin, if the local tradition can be trusted. Mit Afifi resembles the Ashmuni variety in so many ways, however, that it is more likely to have originated directly from the latter. The Mit Afifi variety has very strong and fine, lustrous fiber, averaging $1\frac{3}{8}$ to $1\frac{1}{2}$ inches in length. When typical, it has a light brown color, more pronounced than that of Ashmuni. In Egypt it turns out in ginning from 33 to 35 per cent of lint and its yield on "good average soil" is said to be ordinarily from 500 to 600 pounds of fiber to the acre.

Jannovitch.—This is the most recent variety that is extensively grown. It is said to have developed about thirteen years ago as a cross between Mit Afifi and Gallini, although more likely a mutation from one or the other. It is considered to surpass all other Egyptian varieties in the strength and fineness of its fiber, as well as in length.

---

[a] Pronounced as if spelled Mit Afeefy.

[b] In 1906, 75.5 per cent of the total crop was Mit Afifi, 15 per cent Ashmuni, 5.5 per cent Jannovitch, and 2.7 per cent Abbasi.

averaging $1\frac{1}{2}$ to $1\frac{5}{8}$ inches. Its silkiness, luster, and delicate cream color make it one of the most beautiful cottons in existence. The quality of the fiber from the different pickings is said to be more uniform in this than in the other Egyptian varieties. In yield per acre it is inferior to Mit Afifi, the difference amounting, it is said, to 10 per cent. In ginning, its percentage of lint falls below that of Mit Afifi, averaging 30 to $31\frac{1}{2}$. Notwithstanding this fact, Jannovitch generally brings from $2 to $2.50 more than Mit Afifi per 315 pounds of seed cotton (the unit on which prices are based in Egypt). This variety is said to succeed best on the more or less salty land near the seacoast. It is regarded as more liable than Mit Afifi to premature opening of the bolls and loss of fiber. In 1902, however, when conditions in Egypt were generally unfavorable to cotton, Jannovitch suffered less than did Mit Afifi.

Abbasi.—The Abbasi much resembles the American Sea Island varieties. It has a fine, silky fiber, pure white in color, and somewhat longer but not so strong as that of Mit Afifi. The percentage of lint is about the same as in Mit Afifi. In the Abbasi variety the lint obtained at the first picking is said to be of much better quality than that from later pickings, the difference in this respect being more marked than in other Egyptian varieties. First picking Abbasi sometimes sells for a higher price than any other Egyptian cotton. Abbasi is reputed to be more drought resistant than Mit Afifi and under favorable conditions to give heavier yields. The bolls of Abbasi are exceptionally long and sharp pointed.

Nubari.—Very recently a variety known as Nubari has originated in the Nile Delta. It is described as intermediate between Mit Afifi and Jannovitch, having stronger and more lustrous fiber than the former.

QUALITY AND GRADES OF EGYPTIAN COTTON.

Many grades of each variety are distinguished by importers of Egyptian cotton. The cotton is graded twice, once before ginning and again at Alexandria, where it is rebaled for export. Such characters as strength, fineness, uniformity, color, luster, and percentage of waste are all taken into account in fixing the grade to which a particular sample belongs. The length appears to vary but little in the different varieties. The amount of "trash" present is a very important factor in grading this class of cotton.

Much anxiety has recently been felt in Egypt on account of the evident deterioration of the leading varieties. Mit Afifi especially is showing much less constancy than formerly in the brown color of its fiber, a character that is of much importance in this variety. Spinners also complain that the twist of the fiber, upon which its strength largely depends, is becoming less pronounced. Even re-

cently created varieties like Abbasi and Jannovitch are every year less true to type. The belief in Egypt is that this degeneration is due primarily to lack of care in the choice of seed for planting. It is thought that only careful selection can preserve and improve the varieties and this is now being undertaken both by the government and by individual growers. Special attention is being given to keeping up the brown color and other characters of Mit Afifi, which is justly regarded as the standard Egyptian cotton.

CULTURAL METHODS.

Owing to the cheapness of labor in Egypt, fifteen cents a day being the ordinary wages, the cultural methods in use there could not be followed in the United States without considerable modification. Nevertheless, a brief description of the Egyptian system will undoubtedly afford useful suggestions to those intending to grow cotton under irrigation in the Southwest.

PREPARATION OF THE LAND.

A two-year rotation is most frequently practiced in Egypt and is generally as follows: During the first year, clover (berseem) is grown as a winter crop, followed by cotton in summer. When the cotton is removed, a winter crop of either beans or wheat is sown and is harvested the following June. The land is then either left fallow during the second summer or corn is sown in July as a "flood crop,"[a] and is followed by berseem sown in the autumn. In the third spring cotton is again planted. Formerly it was more common to use a three-year rotation, which resembled the preceding, except that during the second winter either beans or clover were grown and during the third winter wheat or barley, followed by a second crop of corn.

When cotton follows corn or a fallow the land can be put into excellent shape for planting, being generally plowed in the fall as soon as the corn is removed. But if cotton is to be planted immediately after clover, the conditions are likely to be less satisfactory. Much of the cotton is grown by small farmers who are unwilling to plow up the clover upon which they mainly depend for forage for their domestic animals until just before the time arrives for planting cotton. Consequently, the land is apt to be full of undecomposed

[a] This late planting allows the corn crop to be abundantly irrigated throughout its growth, the Nile being at flood during the late summer and early fall months. During the first part of the summer, when the river is lowest, it is often necessary to devote all the available water to the cotton crop, to which, if necessary, everything else is sacrificed.

roots and to be wet, plowing up into clods. A poor stand of cotton and much replanting are the results. Except on the least fertile soils, it is found that the cotton crop is injured rather than benefited by immediately following clover. An intervening crop of grain or a period of fallow is necessary to secure the greatest possible benefit from the clover.

The importance of thorough preparation of the land before planting cotton is fully appreciated in Egypt. Cotton roots descend deep into the soil, and it is found that the deeper the plowing has been the better the plants withstand drought in case of a shortage of irrigation water. On large estates steam plows are now generally used, and the soil is turned over in the fall to a depth of 12 inches. But the great bulk of the cotton acreage is worked with the primitive plow of the country, drawn by a team of oxen, which loosens the soil to a depth of only about 6 inches, without turning it. If, as is now often practiced, a second plow follows the first in the same furrow, the soil can be worked to a considerably greater depth. Four plowings, two at right angles to the others, are usually given in preparing land for cotton. After plowing, the soil is frequently harrowed and then rolled to break up clods. Care is taken, however, not to pulverize the heavier soils too thoroughly, as in that case they tend to bake and crack, thus losing much moisture.

When these operations are completed the land is at once ridged. Ridging is usually done with the native plow, the width of the furrow being increased by stuffing sacking or some other bulky material into the angle between the beam and the share. The ridges are then shaped into beds by men working with the "fass," or short-handled hoe, a tool that is indispensable to the Egyptian agriculturist. The beds are usually made about 36 feet long, this being the average distance between the borders that intersect the beds at right angles, dividing the field into "lands" for irrigation. Cotton is irrigated by the furrow method in Egypt, and this is usually managed so that six or seven furrows can be irrigated together.

Farm manure, which costs about 20 cents a ton in most parts of Egypt, when used at all is put on at the rate of 10 to 15 tons to the acre. Old, well-rotted manure is preferred. Most frequently the manure is applied after the plants are above ground, being either hoed into the furrows or scattered at the roots of each plant, a laborious operation, only possible in a country where labor is as cheap as it is in Egypt. Often, however, the manure is put on before planting. Sometimes it is spread before the ridges are made, but more frequently it is placed in the furrows and subsequently covered up by splitting the ridges. Where cotton immediately follows a crop of berseem, manure is not generally used.

PLANTING.

Planting is done chiefly in March, although, especially in southern Egypt, it sometimes begins as early as the 10th of February. There is a general conviction in Egypt that early planting gives the best results, the stand being better and the plants producing less wood in proportion to fiber. It is believed that better yields and a better quality of fiber are thus obtained. The cold winds frequent in March are said to cause least injury to early-sown cotton. As far as possible replanting should be avoided, since it is difficult to manage the earlier irrigations without injury to some of the plants if these are in different stages of growth.

Cotton is planted closer than in the southern United States, notwithstanding the fact that the plants of Egyptian varieties make a larger growth than American Upland varieties. The average distance between the rows is only about $2\frac{1}{2}$ feet and the "hills" are usually 15 or 16 inches apart in the rows, with two plants in each hill. Hence the average number of plants to the acre is about 26,000. The general opinion in Egypt is that even in the best soils the distance between the rows can not be made more than 3 feet or that between the "hills" more than 2 feet without diminishing the yield.

Seed is planted at an average rate of $1\frac{1}{4}$ bushels per acre. It is put in on the side of the furrow, about two-thirds of the distance from the bottom. In planting, a man with a "fass," or short-handled hoe, goes up and down the rows, making holes at intervals of 15 or 16 inches. He is followed by a boy, who drops into each hole 8 or 10 seeds, covering them to a depth of 2 or 3 inches. Usually ten or twelve days are required for germination.

IRRIGATING.

A watering is usually given immediately after planting, although sometimes the field receives an irrigation just before planting is begun. In the latter case the furrows are filled about two-thirds full and the seed is put in along the high-water mark. When the second or "wet" method of planting is followed, it is easier to put in the seed at a uniform level, but on the other hand the land becomes so dry before it is possible to determine whether replanting will be necessary that another irrigation must first be given, and this delays replanting a week or ten days longer.

The second irrigation generally takes place about thirty-five days after planting. It is found that the best results are obtained if this watering is postponed as long as can be done without injury to the plants. This causes the roots to strike deep into the soil from the outset, stimulates the plant to branch from the base, and prevents the lower part of the stem from making a soft and weak growth which is

later unable to hold up the weight of bolls. This watering is a light one, the water not being allowed to stand high enough in the furrows to reach the plants. From twenty-five to thirty days elapse between the second and third irrigations and about twenty days between the third and the fourth. The fourth usually occurs some time between May 20 and the 1st of June. Thereafter, until the end of August, two waterings monthly are generally given. When the Nile is very low, however, it is sometimes necessary to increase the interval between irrigations to three weeks and to restrict the amount of water that can be applied each time.

Altogether, ten irrigations are commonly given between the date of planting and that of the first picking, care being taken so to time the last watering that the soil will become dry before picking should begin. A watering is given as soon as the first picking is completed, and often one between the second and third pickings. It is estimated that cotton receives at each watering about 3½ acre-inches, or an average total of 3 to 3½ acre-feet of water during the whole season.

The tendency in Egypt, as in other countries where irrigation is practiced, is to apply more water than the crop really needs. Excessive irrigation causes too rank a growth, dropping of the bolls, and late ripening, besides injuring the quality of the fiber. It is well known that in years when the water supply is low and the amount of water that can be applied is restricted by the irrigation service, the crop is frequently larger and of better quality than when a freer use of water is permitted. Thus, in 1899, when the Nile was unusually low, it was observed that in many localities the fiber was longer and finer than that produced the year before, when water for irrigation was more plentiful. There is a minimum, however, below which it is not safe to go in irrigating cotton. In localities where the supply of water is normally small it was quite inadequate in 1899. As a result, the plants were abnormally small, the yields were low, and the fiber was short. It is interesting that in 1899 the product was most inferior in the very districts which in ordinary years have the highest reputation for the quality of their cotton. On the other hand, districts where an excessive amount of water is generally used and where the quality of the fiber is usually inferior, produced the best cotton grown in Egypt in 1899.

CULTIVATING.

Cultivating is performed entirely by hand in Egypt, even on the large estates where modern machinery is used in other agricultural operations. In fact, the cotton rows are too close together to allow the use of a horse cultivator for any considerable length of time after the plants are above ground. The work of cultivating is very onerous,

owing to the universal use of a short-handled hoe, which requires the laborer to assume a stooping position.

On well-managed farms a hoeing is given as soon as the plants are well above ground. It is considered desirable to thin the rows before the second watering, which, as we have seen, is given about thirty-five days after planting. The two strongest plants are then left in each "hill." At the same time some farmers give the beds another hoeing. When the soil has dried sufficiently after the first watering that follows planting, the second (or third) hoeing is given. In the practice of many farmers, however, this is the first hoeing that is given. The third (or fourth) hoeing follows the third irrigation (sixty or sixty-five days after planting), and the fourth (or fifth) hoeing takes place after the fourth watering (eighty to eighty-five days after planting). This is usually the last hoeing, the growth of the plants thereafter making tillage impracticable. From that time until the first picking begins the crop requires no labor except that involved in irrigating. More frequently only three or four hoeings are given, either the first or second, as above described, and sometimes both being omitted by all but the best farmers.

The hoeings are so managed that earth is each time brought up around the plants from the opposite edge of the furrows, which are thus gradually moved in one direction across the field. Consequently the plants, which at the outset stood on the slope of the furrows at the edge of the beds, are at the top and in the center of the beds by the time the third hoeing is completed.

PICKING.

Cotton picking begins in southern Egypt before the end of August, but in the Delta region, where the bulk of the crop is grown, the first picking generally commences about September 10. A second picking is made in October and a third in November. Sometimes a fourth picking is made, while occasionally the whole crop is harvested in two pickings. It is considered especially important with Egyptian cotton to begin picking as soon as enough bolls are ripe to make it worth while, since long exposure to the sun is said to cause the brown color to fade. As a rule 35 per cent of the total crop is harvested at the first picking, 45 per cent at the second, and 20 per cent at the third, but these proportions vary considerably from year to year. The fiber from each picking is graded and marked separately, that from the first picking being generally the best and that from the third picking the poorest. This work is done largely by children, who pick on an average 30 to 40 pounds of seed cotton a day, for which they are paid at the rate of 18 to 20 cents per hundred pounds. The seed cotton is packed in sacks holding about 400 pounds and is then ready for shipment to the ginnery.

GINNING AND BALING.

The product is generally sold where it is grown, as seed cotton, and is transported by the buyer to one of the ginneries which are located in various parts of the cotton-growing region. Most of these establishments operate a large number of gins. Some of them have a daily capacity of 300 Egyptian bales (about 200,000 pounds of lint).

As in the case of Sea Island cotton in the United States, the roller gin alone is used, since the saw gin employed for American Upland cotton injures the long-staple Egyptian varieties. The ginned fiber is shipped, usually in rough bales, to Alexandria. There it passes through compresses and is turned out in the neat bales, bound with eleven hoops, in which Egyptian cotton reaches the European and American markets. These bales, although smaller than the average American compressed bale, weigh from 700 to 800 pounds. They are about one and one-half times as compact as the American bale, the average density being 35.8 pounds per cubic foot in the Egyptian and 23.6 pounds in the American bale.

YIELDS AND MARKETS.[a]

The cotton production of Egypt is large in proportion to the area annually devoted to this crop, which during the four years from 1903 to 1906 averaged 1,500,000 acres. Practically the entire crop, both lint and seed, is shipped to Europe and America, so that the statistics of exports fairly represent the total production of the country. During the nine years from 1898 to 1906 the total exports averaged 611,872,285 pounds of fiber. Assuming that the area in cotton during these years averaged 1,500,000 acres, the yield per acre for the whole country during this period was about 408 pounds.[b] When carefully chosen seed of good varieties is used and the soil and cultural conditions are favorable, yields of 800 and, in exceptional cases, of even 1,100 pounds of fiber are obtained.

Of the total exports of cotton from Egypt during the nine years from 1898 to 1906 about 50 per cent went to the United Kingdom (Great Britain and Ireland). The United States was among the heaviest importers, ranking third in 1902 and second in 1903. Russia, Austria, France, and Italy also imported large quantities. Nearly all of the principal countries in Europe obtain cotton from Egypt, and even India and Japan receive some of the product.

---

[a] The statistics given in the following pages were furnished by Mr. G. K. Holmes, Chief of the Office of Foreign Markets, Bureau of Statistics, U. S. Department of Agriculture.

[b] In 1904 Mr. George P. Foaden estimated the average yield per acre at about 410 pounds. See Bulletin No. 62 of the Bureau of Plant Industry, 1904, p. 43. Mr. A. A. Haserick estimated the average yield per acre to have been only 360 pounds in 1905.

The importation of cotton from Egypt into the United States has been very considerable in recent years. In 1902 the high-water mark of 81,325,158 pounds was reached, but this figure was very nearly equaled in 1907, when 78,783,913 pounds were imported.

The following table shows the amount imported during each of the ten years from 1898 to 1907:

TABLE IV.—*Imports of cotton fiber from Egypt into the United States during the years 1898 to 1907, inclusive.*

Year.	Pounds.
1898	38,165,061
1899	37,506,062
1900	53,554,586
1901	34,735,682
1902	81,325,158
1903	63,554,773
1904	39,249,878
1905	52,436,673
1906	57,860,814
1907	78,783,913
Average	53,717,260

In addition, there has been during the same period an average yearly importation into the United States of cotton from the United Kingdom to the extent of 8,536,357 pounds. The greater part of this is undoubtedly Egyptian cotton.

The table that follows gives the average price per pound of Egyptian cotton in the Alexandria, Liverpool, and Boston markets during each of the ten years from 1898 to 1907. The Alexandria prices are those of cotton that was exported to the United States. The Liverpool prices are those of "good, fair Egyptian." For comparison the average prices of American Middling Upland on the Liverpool and Boston markets during the same period are added.

TABLE V.—*Average prices, in cents per pound, of Egyptian and American Middling Upland cottons on the Alexandria, Liverpool, and Boston markets, from 1898 to 1907, inclusive.*

Year.	Egyptian.			American Middling Upland.	
	Alexandria.	Liverpool.	Boston.	Liverpool.	Boston.[a]
	Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1898	9.3	9.0	10.1	6.7	5.9
1899	9.9	10.7	11.5	7.2	6.5
1900	11.5	15.0	14.7	11.1	9.5
1901	15.0	11.8	13.5	9.6	8.7
1902	11.7	13.9	13.7	9.7	8.9
1903	14.6	17.8	16.1	12.2	11.0
1904	17.9	16.2	17.3	13.4	12.5
1905	15.6	14.8	15.9	10.3	9.3
1906	15.5	19.8	18.7	14.1	11.0
1907	20.3	21.4	21.9	13.2	11.8
Average	14.1	15.0	15.3	10.7	9.5

[a] Mean closing prices for "spot" cotton, compiled from the "Commercial and Financial Chronicle" (published in New York).

The table shows that during the last ten years there has been an advance in the price of Egyptian cotton corresponding closely to the rise in price of American Upland cotton. The ruling price for the latter evidently largely determines that at which Egyptian cotton is quoted. The difference between the Alexandria and the Boston prices, averaging 1.2 cents per pound, presumably represents the cost of transportation, insurance, and other fixed charges between these ports.

The average price of Egyptian cotton on the Boston market during the past ten years has been a little more than one and one-half times that of American Middling Upland, but in 1907 Egyptian cotton sold on the average for nearly twice as much as Upland. It must be remembered that there is a great diversity in Egyptian cotton, some of it bringing much higher prices than are represented by the average for the "good fair" grade. It is a conservative estimate that Egyptian cotton of the quality which experiments have demonstrated can be produced in the southwestern United States will be worth more than one and one-half times as much as Middling Upland cotton. In 1903, when the price of "good fair" Egyptian averaged $14\frac{1}{2}$ cents per pound at Alexandria, a cotton buyer at that place estimated the Jannovitch grown the year before at Calexico, Cal., as worth 21 to 22 cents.

USES OF EGYPTIAN COTTON BY AMERICAN MANUFACTURERS.[a]

The variety of Egyptian cotton that is most used by American manufacturers is Mit Afifi, which constitutes at least three-fourths of the total imports. The grade most largely used averages $1\frac{3}{8}$ inches in length and furnishes numbers of yarns up to 70's and 80's. Jannovitch, and to a small extent Abbasi, averaging $1\frac{1}{2}$ to $1\frac{5}{8}$ inches in length of fiber, are used as a substitute for the lower grades of Sea Island in manufacturing fine yarns (100's and upward). A small quantity of the inferior Ashmuni variety is also imported.

There are four principal reasons for the extensive use of Egyptian cottons in the United States: (1) They are best adapted to mercerizing and other processes that give a high finish to the cloth and cause it to resemble silk; (2) their exceptional clearness (freedom from nep) and luster, as well as their capacity for taking dyes, fit them for mixing with silk and for filling sateen, India linens, and similar goods having a brilliant surface; (3) the brown color of Mit Afifi fiber allows it to be used without dyeing in manufacturing goods such as Balbriggan underwear[b] and lace curtains, in which the ecru

[a] Based upon information obligingly furnished by some thirty of the principal importers and manufacturers of Egyptian cotton in the United States.

[b] Although less in demand for this purpose than formerly.

shade is desired; (4) they can be used for the manufacture of sewing thread and other articles which need to be very strong and for which no other type of cotton but Sea Island is suitable. Owing to the higher price of the latter, Egyptian cottons can in many cases be advantageously substituted.

Among the various classes of goods wholly or partly made from Egyptian cottons may be enumerated lawns, sateens, twills, serges, and fabrics for covering umbrellas, as well as other highly finished cotton cloths. In these goods they are used largely as weft or filling. They are especially suited for making heavy fabrics that must also be soft and fine. Their fineness and luster adapt them to mixing with silk in cloths, floss, and braids. They are largely used in the manufacture of sewing thread and of fabrics for insulating and for bicycle and automobile tires.[a] The lower grades of Mit Afifi are much employed for hosiery yarns.

Except in cases where the brown-colored fiber is especially desired there seems to be little reason for preferring Egyptian to Sea Island cotton, although one manufacturer reports that within the range of the numbers used, the former furnishes a cleaner and better-looking filling than either Sea Island or Peeler (long-staple Upland) cottons. The highest grades of Sea Island have longer and finer fiber than any other cotton and therefore make stronger and finer yarns and thread. For these grades the Egyptian can not be substituted,[b] but in manufacturing various classes of goods the somewhat lower price of Egyptian cottons allows them to be used to advantage in place of the lower grades of the Sea Island, especially when the supply of the latter is below the normal.

On the other hand, manufacturers seem to be generally agreed that for a number of purposes the Egyptian types can not be replaced by American long-staple Upland or Peeler cottons. The former have fiber that is stronger, finer, and more lustrous or "classy" than corresponding lengths of the long-staple Uplands, and give yarns, thread, and cloths that are stronger and clearer (i. e., freer from "nep") than can be made from the latter.[c] There seems to be no

[a] When prices permit, however, Sea Island is preferred for the last purpose, except for the manufacture of goods that are not to be exposed to very hard usage.

[b] One manufacturer of thread states: "We do not know of any Egyptian cotton which can successfully compete with Sea Island for counts [of yarns] finer than No. 110's."

[c] This freedom from nep or knots is one of the most desirable characteristics of goods manufactured from Egyptian cotton. It is somewhat questionable, however, whether it is not partly due to the fact that in Egypt roller gins are exclusively used in separating the fiber.

question of the superiority of the Egyptian over the long-staple Upland varieties in manufacturing strong sewing thread and cloths in which a smooth, lustrous finish is desired.

Apart from specific qualities of the fiber, American manufacturers give other reasons for preferring Egyptian cotton. They state that it is usually more carefully ginned, graded, and baled and is apt to be freer from trash and short fiber, hence giving less waste in carding and combing than either Sea Island or long-staple Upland cottons. Egyptian cotton is also esteemed for its evenness of staple, the different grades showing little variation in this respect from year to year.

EGYPTIAN COTTON CULTURE IN THE UNITED STATES.

AREAS ADAPTED TO THIS TYPE OF COTTON.

The Egyptian varieties are apparently best adapted to culture under irrigation in regions where there is practically no rainfall during the growing season. The only part of the United States where these conditions exist and where at the same time the summers are long and hot enough for profitable cotton culture is the extreme Southwest, from western Texas to southern California.

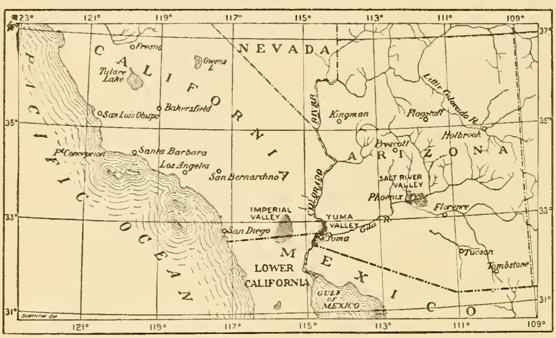


FIG. 1.—Map of Arizona and southern California, showing the location of the Salt River, Yuma, and Imperial valleys.

Since this type of cotton will continue to produce bolls and ripen fiber until a hard frost occurs, it is obvious that the largest yields can be obtained in regions where the autumn temperatures are highest. We must therefore conclude that the greatest success with Egyptian cotton is to be expected in southern Arizona and southeastern California—a conclusion that is supported by the experience so far gained. The valleys of the Salt River and of the Colorado River (Yuma Valley) in Arizona and the Imperial Valley in California have been found to be admirably adapted to the production of this type of cotton. The location of these districts is indicated on the map (fig. 1). It will be well to note briefly the physical characteristics of this region before proceeding to a discussion of the experiments that have been carried on there with Egyptian cotton.

CLIMATE.

Meteorological records covering periods of several years are available for Phoenix and Yuma, Ariz. Data as to temperatures and atmospheric humidity at these localities have already been given in connection with the discussion of the climate of the cotton-growing district in Egypt. These two stations represent, respectively, the Salt River Valley and the Yuma Valley. In the Imperial Valley observations have been taken only during the past three years and under conditions that make a direct comparison with Phoenix and Yuma of doubtful value.

Temperatures (see Table I) are slightly higher at Yuma than at Phoenix, the annual mean temperature, mean of the maximum, and mean of the minimum temperatures being each 2 degrees F. higher at the former locality. At Yuma the mean of the annual absolute maximum temperatures is 113° and that of the annual absolute minimum temperatures is 29° F. It should be noted, however, that in the Yuma Valley itself the minima are undoubtedly lower than at the Yuma Weather Bureau station where observations are taken, the latter being situated at a somewhat higher elevation, adjoining the mesa which borders the valley. Severe frosts frequently occur in the valley from the middle of November to the first of March.

The rainfall at both Phoenix and Yuma is so small as to be practically negligible from the point of view of cotton culture. At Phoenix it is 6.8 inches yearly, while at Yuma the average is only 2.7 inches. The difference is most pronounced in the summer and early autumn, when there is considerable precipitation in the Salt River Valley, but practically none in the valley of the Colorado.

As regards atmospheric humidity (see Tables II and III), the air normally contains considerably more moisture at Yuma than at Phoenix. This is true in every month of the year except January, although the difference is most pronounced during the months from May to September. The mean annual relative humidity (in percentages of saturation) is 38 at Phoenix and 46 at Yuma. The mean annual absolute humidity (in weight in grains of the water vapor in a cubic foot of air) is 2.8 at Phoenix and 3.9 at Yuma.

In the Imperial Valley the temperatures are probably normally higher than at either Phoenix or Yuma. This is indicated by the fact that in 1906 the annual mean of the maximum temperatures at Heber (8 miles south of Imperial and 57 miles due west of Yuma) was 88° F., while at Yuma it was 85° and at Phoenix 83° F. On the other hand, the annual mean of the minimum temperatures was the same at Heber as at Phoenix (56° F.), but was 2 degrees lower than at Yuma. The annual mean temperature at the three

localities in 1906 was as follows: Heber and Yuma, 72°; Phoenix, 70° F.[a]

The rainfall in the Imperial Valley is probably about the same as at Yuma. At Salton, Cal., the nearest locality at which measurements have been made during a series of years, the average total yearly rainfall is 2.5 inches.

Data are lacking for a satisfactory comparison of the atmospheric humidity in the Imperial Valley with that in the Salt River and Yuma valleys, but there is reason to believe that the air is normally drier in the Imperial Valley than at either of the Arizona localities.

As has already been remarked, the climate of southern Arizona and southeastern California is more extreme than that of the portion of Egypt where cotton culture is carried on, the summers being hotter and the winters colder; furthermore, the mean humidity of the atmosphere is much lower in the southwestern United States than in the Delta of the Nile. In Egypt the comparatively moist condition of the atmosphere that prevails during the period when cotton is ripening is considered an important factor in the production of a high quality of fiber, but experience in the southwestern United States has demonstrated that the Egyptian varieties of cotton can adapt themselves to a much drier atmosphere than that prevailing in the Nile Delta without injury to the quality of their fiber.

In point of temperature the climate of southern Arizona and southeastern California is an ideal one for cotton of the Egyptian type, which differs from Upland varieties in requiring a much longer season and a much greater sum total of heat in order to produce its maximum yield of fiber. The usual absence of killing frosts after the 1st of March makes it possible to plant earlier than in most parts of the cotton belt of the United States. The long, very hot summer permits the formation of the greatest possible number of bolls. Finally, the warm weather that ordinarily prevails until the 1st of December is highly favorable to ripening and allows four or five pickings to be made.

Another great advantage in growing this type of cotton in the Southwest is the very small precipitation. Cotton growing under rainfall has certain disadvantages that are avoided when the crop is produced under irrigation in a nearly rainless region. In the main cotton belt of the United States preparation for planting must often be delayed until the ground dries out sufficiently to be worked. Dry

[a] In comparing these records it must be borne in mind that at Heber the observations were made at a height of only 5 feet from the surface of the ground, while at Yuma they were made at a height of 16 feet, and at Phoenix of 47 feet.

spells may occur in spring when the plants should be making their most vigorous growth. Prolonged wet spells in late summer and early fall may retard ripening, interfere with picking, and injure the ripe fiber by beating it out of the open bolls and discoloring it. Under irrigation in regions of little rainfall these drawbacks are avoided. The soil moisture is under the control of the farmer. By giving relatively large amounts of water during the early stages the plants are stimulated to make a vigorous growth. Later in the season, the production of bolls and the ripening of the fiber can be hastened by using water sparingly. Furthermore, the ground need never be wet at the time when picking should commence, and there is no danger of the discoloration of the fiber through a period of rainy weather at the time of ripening. This is a very important consideration as regards the principal Egyptian varieties of cotton, in which good color is a valuable characteristic.

Apart from the general advantages that irrigation affords in connection with cotton growing there is some reason to believe that it is characteristic of the Egyptian varieties to give better results when grown in regions of small rainfall where artificial watering is necessary. An expert on the subject in Egypt [a] told one of the writers in 1902 that Egyptian varieties, when tested in the Sudan, underwent from 15 to 20 per cent of deterioration in localities where the rainfall was sufficient to produce a crop, but deteriorated only 2 to 3 per cent where irrigation had to be practiced. In the former case the staple was shorter and the seeds tended to become covered with short fiber.

SOILS.[b]

The soils of the Salt River, Yuma, and Imperial valleys vary in texture from a sandy loam to a heavy clay, or adobe. In the Imperial Valley the average soil is heavier than in the Salt River and Yuma valleys, resembling much of the soil of the Nile Delta. These soils often show great diversity in a field of a few acres, the variation

---

[a] Mr. Benachi, of the firm of Choremi, Benachi & Co.

[b] For a fuller account of the soils of the Colorado River region, the reader is referred to the following publications of the Bureau of Soils, United States Department of Agriculture: (1) Soil Survey in Salt River Valley, Arizona, by Thomas H. Means; Field Operations of the Division of Soils in 1900, pp. 287 to 332, 1901. (2) Soil Survey around Imperial, Cal., by Thomas H. Means and J. Garnett Holmes; Field Operations of the Bureau of Soils in 1901, pp. 587 to 606, 1902. (3) Soil Survey of the Yuma Area, Arizona, by J. Garnett Holmes; Field Operations of the Bureau of Soils in 1902, pp. 777 to 791, 1903. These publications give the area and distribution of the different types of soils in the three valleys and also the area and distribution of the different grades of alkali soils.

being especially noticeable when the land is first brought under cultivation. The lighter soils are generally regarded as the best for cultivated crops; they work readily, are easily kept in a tillable condition, and can be cultivated soon after irrigation.[a] The heavy soils are well adapted to growing alfalfa and cereals. It may be observed that the physical condition and water-holding capacity of most southwestern soils could be greatly improved by the addition of organic matter in the form of barnyard manure, by plowing under green-manure crops, or by including alfalfa in a long-period rotation.

While for the most part the soils of the Salt River, Yuma, and Imperial valleys are naturally very fertile, it is probable that if cotton becomes an important crop in the region leguminous crops will have to be grown in rotation with it in order to keep up the supply of nitrogen, since the cotton plant draws heavily upon this element.

Alkali is found in more or less injurious quantities in various parts of these three valleys. As a rule the alkali accumulations are found principally in the upper 3 or 4 feet of soil and are often largely concentrated in the surface foot, to which they are raised by capillary activity, aided by the great evaporation which is characteristic of that region. The alkali is chiefly the less injurious "white alkali," consisting mainly of sodium chlorid and sodium sulphate. "Black alkali" (sodium carbonate), which gives the soil an alkaline reaction in the true chemical sense, is seldom present in dangerous quantities. It is probable that only a small percentage of the total area capable of irrigation in the Salt River, Yuma, and Imperial valleys contains enough of these salts to seriously hinder the growing of cotton, which, as has already been stated, is one of the most alkali-resistant crop plants.

WATER SUPPLY.

In the Salt River Valley the area at present in cultivation, which was estimated in 1900 to amount to 120,000 acres, is supplied with water by a number of canal systems that have been established by private capital. The United States Reclamation Service has recently undertaken the irrigation of this valley, and is now constructing a great impounding dam on the Salt River above Phoenix, which will increase the acreage under irrigation and insure an adequate supply of water at all times. The Government system is expected to provide water for irrigating 200,000 acres of land, including that which is now in cultivation.

[a] In Egypt, however, the heavier soils are preferred for cotton culture.

In Yuma Valley only about 3,000 acres are now under irrigation throughout the year, all of this land being situated within a few miles of the town of Yuma. The water used in irrigating this area is pumped from the Colorado River. The United States Reclamation Service is now constructing an irrigation system, including a large diversion dam on the Colorado, which will provide gravity water for approximately 90,000 acres, four-fifths of which is located on the Arizona side of the river.

The Imperial Valley comprises approximately 500,000 acres of irrigable land in the United States, of which about 100,000 acres were actually under irrigation in 1905. This area is supplied with water from the Colorado River, the irrigation system being owned by a private corporation.

There are also a number of smaller areas along the Colorado and Gila rivers that are, or can be, irrigated with water from these rivers.

The total area that will be under ditch in the course of a few years in the Colorado River region can be conservatively estimated at 600,000 acres. During the last ten years the United States has imported an average amount of Egyptian cotton equivalent to about 120,000 American bales. Since the performance of the Mit Afifi variety at Yuma in 1907 gives good ground for anticipating yields of one to two bales to the acre in this region, it may be reasonably expected that one-fifth of this estimated total acreage will be able to supply the normal American demand for cotton of the Egyptian type.

Other districts in the Southwest where cotton can be grown under irrigation, but where the spring and fall temperatures are perhaps too low for the greatest success with Egyptian varieties, are the Pecos Valley in western Texas and eastern New Mexico and the southern part of the San Joaquin Valley in California.

EXPERIMENTS IN THE SOUTH ATLANTIC AND GULF STATES.

Seed of the principal Egyptian varieties of cotton (Mit Afifi, Jannovitch, Abbasi, and Ashmuni) has been several times imported by the Department of Agriculture and furnished to individual growers in various parts of the southern and southwestern United States. In 1900 and 1901 Mr. L. H. Dewey, in charge of fiber investigations, received numerous reports of trials of seed distributed by the Department of Agriculture which indicated that in the humid portion of the cotton belt little success could be anticipated with the Egyptian varieties. An excellent quality of fiber was produced at several localities, but the yields were generally small, due largely to the shortness of the season, which prevented many of the bolls from ripening. In many cases planting was delayed by wet weather in the spring, and

killing frosts occurred so early in the fall as to cut off a large part of the crop.[a]

Dr. Herbert J. Webber[b] experimented for several years with Egyptian varieties in the humid section of the United States, especially in South Carolina and Texas. His results also indicate that these varieties can not be profitably grown anywhere in the main cotton belt, at least not without adaptation through several years of acclimatization and selection.

PRELIMINARY EXPERIMENTS IN THE SOUTHWEST.

Experiments carried on in Arizona by the Territorial Agricultural Experiment Station and by individual farmers previous to 1902 pointed to the conclusion that heavy yields of Egyptian cotton of high quality could be obtained under irrigation in the warmer part of the arid region. The Abbasi, Mit Afifi, and Jannovitch varieties were grown by Prof. A. J. McClatchie on the station farm at Phoenix and were productive in the order named, Abbasi yielding at the rate of 460 pounds of lint to the acre. The Lowell Textile School reported that the Mit Afifi cotton grown at Phoenix, as compared with imported Mit Afifi, gave 4 per cent less waste and furnished thread that was 14 per cent stronger.

In 1902 preliminary experiments were made by Messrs. Webber and Kearney, of the Bureau of Plant Industry, at a number of localities in the Southwest as follows: Mit Afifi variety at San Antonio and Barstow, Tex., and at Carlsbad, N. Mex.; Jannovitch variety at Barstow, Tex., Carlsbad, N. Mex., Yuma, Ariz., and Calexico, Cal., and Ashmuni variety at Del Rio, Tex. In addition, Doctor Webber experimented in the same year with the Mit Afifi variety at Hartsville, S. C., and at Houston and Brownsville, Tex.; with the Jannovitch variety at Denison, Tex., and with the Ashmuni variety at Danville, Ga., and Waco, Tex.

REPORTS OF EXPERTS ON THE FIBER PRODUCED IN 1902.

Fourteen samples, representing each Egyptian variety from each locality where it was grown in 1902, were submitted to seven American cotton buyers. The Jannovitch, grown at Calexico, Cal. (about

---

[a] In Circular 26 of the Division of Botany, U. S. Department of Agriculture, 1900, Mr. Dewey describes the results of experiments with Egyptian cotton in the United States up to that time. In these earlier experiments perhaps the most promising results were obtained by Mr. W. H. Wentworth at Floresville, near San Antonio, Tex., indicating that success is to be looked for west of the main cotton belt.

[b] Doctor Webber has described his experiments in Proceedings of the Seventh Annual Convention of the Southern Cotton Spinners' Association, pp. 127–138, 1903.

60 miles west of Yuma), was highly commended by all of these experts. Two of them rated it highest among the fourteen samples, while four rated it as equal to any. Only one expert gave the preference to another of the fourteen samples.

The same series of samples was sent to Mr. William Getty, buyer of cotton at Alexandria, Egypt, for a firm at Providence, R. I.[a] His report showed the Jannovitch fiber produced at Calexico to be the best of the lot. Mr. Getty said of it: "Length of fiber, quite 2 inches;[b] strength very good; uniformity, good; very fine; rich in color; spinning quality very high; valuation at present market conditions [August 4, 1903], 21 to 22 cents per pound; is especially adapted for sewing cotton and for same purpose as Sea Island; is equal to the best Jannovitch in all respects and could not be improved upon."

The Lowell Textile School, to which eleven of these samples were also submitted, reported through Mr. O. L. Humphrey, head instructor in the cotton yarn department, on the Jannovitch grown at Calexico in the following terms: "Staple fully 1½ inches. Fiber very strong, fine, and even. Very small amount of unripe or short fiber. Cotton clean and in fine condition. Use for 60's carded, 70's and 80's combed."[c] These are higher numbers of yarns than were furnished by any of the other samples and indicate a fiber of superior fineness. Mr. Humphrey adds, "An examination of the various samples would indicate that of the three varieties Jannovitch was decidedly the best."

Manufacturing tests of the eleven samples were made with great care by the Lowell Textile School.[d] The cotton was "picked" (i. e., loosened in preparation for combing), combed, roved, and spun into yarn with the same degree of care and following the same methods used by manufacturers who handle corresponding grades of imported Egyptian cotton. Exact determinations were made of the amount of waste occurring during each process and of the strength of the yarn produced.

The waste includes moisture lost during the different manufacturing processes, dust, fragments of leaves, of bolls, and of seeds, and

---

[a] Mr. Getty, who had had thirty years' experience in the cotton business in Egypt, also referred the samples to several experts in Liverpool, who confirmed his opinion.

[b] This was a higher rating as to length than was given by any of the American experts, who placed the length at 1½ or 1⅝ inches.

[c] Long-staple cottons are usually combed as a preliminary to spinning, while short-staple cottons are generally carded.

[d] The Lowell Textile School also submitted the samples to Mr. F. S. Kerrigan, expert of a manufacturing company at Lowell, Mass., who examined them independently and whose report corroborated Mr. Humphrey's to a remarkable degree.

short fiber. It is stated in percentages of the weights of the original samples. The total waste from the sample of Jannovitch grown at Calexico amounted to 23 per cent and from the sample of the same variety grown at Yuma to 26 per cent. The average for the eleven samples grown in the United States was 26 per cent, while a sample of imported Mit Afifi [a] secured from a New England mill, which uses large quantities of this cotton, showed 27 per cent of total waste. The normal waste from imported cotton of this variety handled in the same way is estimated by Mr. Humphrey at about 24.2 per cent.

The manufacturing tests gave the following results, according to Mr. Humphrey's report:

> The running of the samples in the roving processes was excellent. * * * The roving made was exceptionally strong and even. * * * The samples of "Jannovitch" [from Calexico, Cal.; Yuma, Ariz., and Denison, Tex.] ran in the spinning almost without a break and showed in this process remarkable strength. In order to compare the strength of the warp yarns of the various samples, 40 skeins of 120 yards each of every sample were reeled, the ends tied, broken, and weighed. The skein breaking was done on a power-driven yarn tester giving uniform speed.

The strength is stated in terms of the average weight in pounds that was required to break each skein of each sample. The samples of Jannovitch grown at Calexico and at Yuma proved to be decidedly the strongest of the eleven samples, 66 pounds having been the average weight required to break the former, and 74 pounds the latter, while the general average for the eleven American-grown samples was 55.5 pounds. For the sample of imported Egyptian the average breaking strength was 45.5 pounds. Taking the strength of Draper's Standard Warp as 100, the Jannovitch cotton grown at Calexico had in comparison a strength value of 146.5 and that grown at Yuma of 164.5, while the imported Mit Afifi had a strength value of only 101, which was surpassed by nearly all the American samples. This difference is explained by Mr. Humphrey as "largely due in many cases to the greater length of staple, although the strength and spinning qualities of the staple are unquestionably instrumental in producing this result."

The samples of Jannovitch grown at Calexico and Yuma were adversely criticised by Mr. Humphrey in respect to only one characteristic, i. e., the presence of a considerable amount of "nep" in the finished yarns. Mr. Humphrey says, however, that they "will compare fairly well in this respect with the bulk of the Egyptian yarn of this number which is being manufactured at the present time."

[a] Mr. Humphrey says of this sample, "This variety (grade and length) is, however, considered a fair average Egyptian cotton and one that is very largely and generally used in this country."

Mr. Humphrey concludes his report as follows:

An examination of these American-grown Egyptian cottons and an inspection of the table of results as here given shows them to be, as a rule, long stapled, unusually strong, uniform and satisfactory in color, clean, and possessed of good spinning qualities. The per cent of short fibers compares very favorably with that of the imported article, but the amount of unripe fiber in some of the samples is excessive. This may perhaps be due to the fact that the cotton was raised in limited amounts, and in order to secure the greatest possible quantity of each, the picking was more thorough and included a larger per cent of the contents of the unripe or partially ripe bolls than would have, under ordinary conditions, been gathered. From the results of these tests we can naturally infer that there is a flattering future for American-grown Egyptian cotton, provided the standards can be maintained. This stock admits of the production of much finer numbers and better qualities of yarn than could be made from Upland, Texas, or Gulf cotton, and is inferior only to Sea Island cotton.

RESULTS OF ACCLIMATIZATION AND SELECTION IN THE SOUTHWEST.

In 1902 numerous selections were made in the test plats of the Mit Afifi and Jannovitch varieties at Barstow, Tex.; Carlsbad, N. Mex.; Yuma, Ariz., and Calexico, Cal. These selections were planted in 1903 at the same four localities on the "plant to the row" system. In addition a test plat of the Abbasi variety was grown at Carlsbad. In 1904 the selections of Mit Afifi and Jannovitch made in 1903 were planted only at Carlsbad and Yuma. In 1905 the selections made in 1904 were planted at the same two localities, but those at Yuma were lost soon after planting, as a result of the unprecedentedly high spring flood of the Colorado River. A large number of selections were made at Carlsbad, however, and with these the work has since been continued at Yuma.[a]

The Abbasi variety was soon discarded because it too nearly resembles Sea Island cotton, with which it would undoubtedly compete in American markets. It was desired from the outset to secure a type of cotton for culture in the Southwest that would be distinctive of that region as compared with other cotton-growing sections in the United States. The best means of attaining this end appeared to be by acclimatizing the very distinct Mit Afifi and Jannovitch varieties, especially the former.

Numerous selections of Mit Afifi have been carried through five generations and have fully retained the distinguishing characters of the variety. Through a series of accidents the original selections from imported seed of the Jannovitch variety were lost, but certain selections from the more or less mixed seed of the Mit Afifi variety with which the experiments were begun have so nearly approximated the

[a] In 1904 and 1905 the selections were made by Mr. L. L. Harter.

characters of Jannovitch that there seems to be no good reason for making new selections from imported seed of the latter.

Throughout the course of the experiments the plants have been grown under irrigation on the best land and with the best care as to irrigation, cultivation, etc., that circumstances admitted. It was not until last year, however, when the work was carried on in association with the Office of Western Agricultural Extension Investigations of this Bureau, that it became possible to raise the cotton under favorable conditions as regards cultivation and irrigation. Previous to 1907 these selections were exposed to so many vicissitudes—drought, alkali soils, inadequate cultivation, etc.—that there is good reason to believe that they are exceptionally hardy and well adapted to growing under conditions below the optimum for cotton culture in the region.

CHARACTERS OF THE PLANTS.

During the earlier years of the experiments it was extremely problematical whether Egyptian cotton would adapt itself to conditions in the Southwest. The plants made a very vigorous growth, but produced relatively few bolls, as is shown in Plate II, figure 1. These bolls matured so late in the season that many of them were cut off by frost before they opened. The opening of such bolls as ripened was generally very unsatisfactory, the valves of the locks remaining half erect instead of spreading horizontally, so that in picking the fiber had to be pulled out between the points.

Each year, however, a marked improvement in yield, earliness, and the degree of opening of the bolls manifested itself. In 1906, whether through acclimatization or selection or a combination of the two agencies, such a great improvement had been attained that there seemed little occasion for further anxiety on these scores. The Egyptian plants were still, it is true, much larger and ripened their fiber later than those of most Upland varieties grown under similar conditions, and their bolls remained small and pointed (Plate IV). All these, however, are characters inherent in the species of cotton (*Gossypium barbadense*) to which the Egyptian and Sea Island varieties belong, as distinguished from that which includes the American Upland varieties (*Gossypium hirsutum*). No amount of selection can be expected to entirely remove them. But, as compared with the performance of the plants in previous seasons, there had been a marked reduction in height and in the development of sterile branches (Plate III). The relative number of bolls produced was much larger and the fiber ripened much earlier than in any previous year. Furthermore, the bolls opened out flat, so that the cotton hung as loose as from bolls of Upland varieties.

In 1907 these characteristics had become practically uniform over the entire field (Plate I, frontispiece), not only in the selection rows but in the one-fourth-acre plats that were planted with seed from second-select plants of 1906 for yield tests and for experiments with different irrigation and cultivation methods. Before the middle of September the cotton was ready for the first picking. It was therefore at least a month earlier than was the case during the first three years of the experiments. The satisfactory opening of the bolls is shown in Plate IV, while Plate II, figure 2, illustrates the manner in which the ripe cotton hung loosely in the open bolls. Careful records of the time consumed in picking at Yuma in 1907 showed that it required only about one and one-half times as long to pick 100 pounds of seed cotton of the Mit Afifi Egyptian as of large-bolled Upland varieties, such as Triumph and Rogers Big Boll.

YIELD TESTS.

Yield tests of two Egyptian and five American Upland varieties of cotton were made at Yuma in 1907 on plats ranging in size from one-tenth to one-sixth acre. The results in pounds of seed cotton, calculated on the basis of 1 acre, are given in the following table:

TABLE VI.—*Results of yield tests of cotton varieties at Yuma, Ariz., in 1907, in pounds of seed cotton and estimated pounds of lint produced per acre.*

Variety.	Pounds of seed cotton per acre.		Estimated percentage of lint.	Estimated total yield of lint.
	Ripened before Dec. 1.[a]	Total yield.		
				Pounds.
Mit Afifi (Egyptian)	2,880	3,300	[b] 30	990
Jannovitch (Egyptian)	1,851	2,228	30	668
Rogers Big Boll (short-staple Upland)	2,897	2,975	34	1,011
Triumph (short-staple Upland)	2,571	2,660	37	984
Sunflower (long-staple Upland)	1,950	2,235	30	670
Southern Hope (long-staple Upland)	2,572	3,052	30	915
Columbia (long-staple Upland)	2,101	2,456	30	737

[a] The amounts of seed cotton that ripened before December 1 are inserted because the autumn of 1907 was unusually warm, and it is possible that the figures in this column more nearly represent the yields that can normally be expected than do the total yields in 1907. The amounts that ripened after December 1 were estimated by dividing the total amount of seed cotton secured at the last picking by the number of days that had elapsed between this and the preceding picking and multiplying the result by the number of days between December 1 and the date of the last picking. The results are necessarily only approximate, since the amount of cotton that ripened daily must have decreased toward the end of the season.

[b] A 50-pound sample of seed cotton of this lot was very carefully ginned on a roller gin and gave 33.5 per cent lint. On the other hand, a 200-pound sample yielded only 29.1 per cent. Thirty per cent would therefore appear to be a conservative estimate. Since in Egypt the Mit Afifi variety is said to give from 33 to 35 per cent of lint, there is every reason to believe that the percentage of lint of this variety in the Southwest can be materially improved over that obtained in 1907 at Yuma. The estimated percentage of lint for the other varieties in Table VI are based upon the average performance of these varieties in other localities.

Notwithstanding the fact that in two of the Upland varieties the percentage of lint is considerably higher than in Egyptian varieties, only one of them surpassed the Mit Afifi in productiveness, and that

to but an inconsiderable extent. The lower yield of the Jannovitch Egyptian as compared with the Mit Afifi is doubtless partly due to the fact that the Jannovitch plat in 1907 was planted with seed from plants grown in 1906 from an imported stock, while the stock of Mit Afifi had had the advantage of five years' acclimatization in the Southwest.

QUALITY OF THE FIBER.

During the earlier years of the experiment it seemed so essential to concentrate every effort upon combating sterility, late ripening, and imperfect opening of the bolls that in making the selections only secondary weight could be placed upon the quality of the fiber.

The Jannovitch variety, nevertheless, produced an excellent grade of fiber from the start. This was probably due to the recent origin of this variety, which had not had time to deteriorate seriously since it left the hands of the breeder. As has been stated, the fiber produced by this variety grown from imported seed at Calexico, Cal., and Yuma, Ariz., in 1902 was given a high rating by the Lowell Textile School and by expert cotton buyers in the United States and in Egypt. The Jannovitch variety was again grown from imported seed at Yuma in 1906, and the seed thus obtained was used in planting the yield-test plat of this variety in 1907. In this case also the American-grown product compared far more favorably with the average of the variety in Egypt than did the Mit Afifi variety during the first two or three years after it was introduced.

The fiber produced by the Mit Afifi variety during the earlier years of the experiments in the Southwest was of decidedly inferior quality. As compared with the best grades produced in Egypt, the lint was relatively short, in hardly any case reaching a full $1\frac{3}{8}$ inches. It was coarse and woolly and of a dead appearance, lacking the fine luster that is one of the most attractive qualities of high-grade Egyptian cotton. Very few plants showed even an approximation to the great strength that is one of the leading and most valuable characteristics of this type of cotton. In color also it left much to be desired, the brown tint being either nearly wanting or so irregularly distributed as to give the cotton a blotched appearance, as though artificially discolored.[a]

In 1905, the tendencies to sterility, late ripening, and imperfect opening of the bolls in the Mit Afifi variety having largely disap-

[a] From the fact that the results obtained during the first year or two of the experiments were much more satisfactory with the Jannovitch than with the Mit Afifi variety, it might be inferred that when first imported the former is better adapted than the latter to southwestern conditions. More likely, however, the Mit Afifi seed originally imported was of inferior quality. As heretofore stated, this variety is deteriorating in Egypt and becoming mixed with inferior sorts except where it is kept up by careful selection.

peared, it became possible to focus attention upon the characters of the fiber. As a result, in 1906 the fiber showed a marked improvement in all of its characters, and this was true to a still greater extent in 1907. In the latter year selection was made so rigorous that the best individual plant of 1903 would have failed to pass muster. In the 1 acre of breeding rows planted with seed from the first-select plants of 1906, the length averaged practically $1\frac{1}{2}$ inches. The thirty-eight first selections of individual plants made in 1907 had fiber of an average length of $1\frac{9}{16}$ inches, as compared with an average of $1\frac{1}{2}$ inches for the thirty-one first selections made in 1906. In other words, a gain of 4 per cent in length had been made in one generation. This is probably the maximum length to which the Mit Afifi type of Egyptian cotton should be bred to meet the demands of the existing market.

In all other characters—covering of the seed, uniformity of length on the same seed and in different bolls on the same plant, strength, color, fineness, and luster—the advance was so striking that it was in some cases difficult to realize that the plant of 1907 was only in the fifth generation of descent from its progenitor of 1902 (Pl. V).[a] No one characteristic showed more gratifying progress than that of strength. While in 1903 the plant producing fiber that could not be broken easily between the fingers was a rare exception, in 1907 it was the general rule. Fiber of great fineness, soft and silky to the touch, was also the rule. Brown color characterized the fiber on the great majority of the plants, and was almost as general and pronounced as in any field seen in Egypt by one of the writers. In plants which preserved the Mit Afifi type the brown tint was conspicuous, especially when a mass of the fiber was examined, although much lighter than in the red-brown Peruvian and Nanking cottons. In plants that showed an approximation to the Jannovitch type, the fiber was of a delicate cream color, appearing almost white when compared with Mit Afifi, but showing clearly the brown tint when matched with American Upland fiber. The Jannovitch type was furthermore remarkable for the silky luster of the fiber.

Strength tests.—Careful tests of the strength of several samples of Egyptian cotton grown at Yuma in 1907 were made by the Office of Fiber Investigations of the Bureau of Plant Industry. The tests were made on a special fiber-testing machine. The samples submitted were as follows: No. 1, Mit Afifi, from a plat which received eight irrigations after planting; No. 2, Mit Afifi, from a plat which received only one irrigation after planting; No. 3, Mit Afifi, from a plat which received three irrigations after planting; No. 4, the average of the first picking from seven individual selected plants of

[a] During each year of the experiments combed-out seeds of every selection have been preserved as a record of the progress made in breeding.

Mit Afifi in the breeding rows which had received four irrigations after planting; No. 5, the average of the later pickings from the same seven selections. Jannovitch from the yield-test plat, which was irrigated twice after planting, was also tested. The Mit Afifi had in every case been grown five years in the Southwest, while the Jannovitch was from that grown at Yuma in 1906 from newly imported seed.

In order to permit a comparison of the strength of the Arizona-grown Egyptian samples described above with that of cotton of other varieties and from other sources, the Office of Fiber Investigations also furnished the results of a series of tests made by Mr. Frederick J. Tyler upon different Upland and Sea Island varieties, as well as upon three varieties of Egyptian cotton. All of these were grown by Mr. Tyler without irrigation at Waco and Terrell, Tex., with the exception of the two samples of Southern Hope (long-staple Upland). The latter were produced under irrigation at Yuma, Ariz., in 1907.

The results as stated in the following table represent the average of the weights in grams required to break each of twenty individual fibers from each sample:

TABLE VII.—*Breaking strength of samples of Egyptian and other cottons grown under irrigation in Arizona and without irrigation in Central Texas.*

Type of cotton.	Variety.	Where grown.	Number of irrigations.	Breaking strength.
				Grams.
Egyptian	Mit Afifi, No. 1	Arizona	8	4.6
	Mit Afifi, No. 2	Arizona	1	6.5
	Mit Afifi, No. 3	Arizona	3	6.4
	Mit Afifi, No. 4	Arizona	4	5.9
	Mit Afifi, No. 5	Arizona	4	6.2
	Mit Afifi	Texas	None.	4.5
	Jannovitch	Arizona	2	6.4
	Jannovitch	Texas	None.	4.0
	Ashmuni	Texas	None.	5.5
Upland long-staple	Allen	Texas	None.	3.5
	Boozer	Texas	None.	3.4
	Florodora	Texas	None.	3.1
	Griffin	Texas	None.	3.5
	Peeler	Texas	None.	4.1
	Sunflower	Texas	None.	3.4
	Southern Hope, No. 1	Arizona	8	6.0
	Southern Hope, No. 2	Arizona	1	5.0
Upland short-staple	Culpepper	Texas	None.	5.1
	Cook Improved	Texas	None.	7.0
	Drake	Texas	None.	4.5
	Excelsior	Texas	None.	5.3
	Jones Improved	Texas	None.	5.2
	King	Texas	None.	4.8
	Mortgage Lifter	Texas	None.	5.9
	Russell	Texas	None.	5.5
	Truitt	Texas	None.	6.0

In regard to the Egyptian cottons grown under irrigation at Yuma it is interesting to note the relative weakness of the fiber in Mit Afifi sample No. 1, from a plat that was excessively irrigated, as compared with samples 2 and 3, from plats that received only one and three irrigations, respectively, after planting. The selections

(samples 4 and 5) were irrigated four times after the seed was put in. In the case of the selections an unexpected result is the greater strength shown by the later pickings (sample 5) as compared with the first pickings (sample 4) from the same individual plants. In Egypt, on the other hand, the fiber from the first pickings is reputed to be generally stronger than that which is picked later in the season.

It will be observed that the long-staple Upland or Peeler varieties are generally very inferior in strength to the short-staple Uplands. A notable exception is the Southern Hope, which was grown under irrigation at Yuma. It is rather remarkable that in this case sample No. 1, which received eight irrigations after planting, is decidedly stronger than sample No. 2, which was watered only once after the seed was put in. On the other hand, the Mit Afifi Egyptian, which received eight irrigations at Yuma (sample No. 1 in Table VII), was decidedly inferior in strength to that which was irrigated only one to four times (samples 2 to 5). The Mit Afifi and Jannovitch Egyptian varieties, grown under rainfall in central Texas from imported seed, appear to be deficient in strength as compared with the same varieties under irrigation in Arizona.

From the manufacturer's point of view, tests that are based upon the breaking point of individual fibers are not alone satisfactory indicators of the strength of a given sample of cotton. They should be supplemented by tests of the breaking strength of the thread, which depends not only upon the strength but the length and fineness of the individual fiber, the last character determining the number of fibers which can be spun into a thread of given diameter. But when the great fineness and the satisfactory length, as well as the great strength of the individual fibers of the Egyptian cotton produced in Arizona in 1907 are taken into consideration, we can be reasonably certain that they will furnish a very strong thread.[a]

Comparison of the fiber from different pickings.—In view of the belief prevailing in Egypt that fiber from the first picking is decidedly superior to that from the second and third, the products of the first and of the later pickings from some of the best selected plants of the Mit Afifi variety at Yuma in 1907 were carefully compared. In point of strength, as has been noted, the fiber from the later pickings, which were taken together, was found to be uniformly somewhat superior to that from the first, but in the other characters no pronounced difference was observed, except that in two or three cases the length was slightly inferior in the later pickings. In color the later pickings were in all cases equal to the first.

[a] The results of the strength tests of yarns spun from the Jannovitch cotton grown at Calexico and Yuma in 1902 support this belief.

OPINIONS OF EXPERTS ON THE FIBER PRODUCED IN 1907.

Small samples of the acclimatized Arizona-grown Egyptian cotton produced in 1907 were submitted to 22 American buyers and manufacturers of this type of cotton, of whom 18 reported their opinions of its quality and 11 furnished estimates of its value at current market prices. The prices varied considerably, ranging from 18 to 26 cents a pound, the average of all the estimates obtained being 20.6 cents. At the time when these estimates were furnished (February 15 to March 7, 1908) American Middling Upland cotton was selling on the Boston market for 12 to 12½ cents a pound, and imported Egyptian cotton for 12 to 15½ cents ("low grades"), 14 to 18 cents ("current grades"), 16½ to 19 cents ("good grades"), and 17½ to 21 cents ("high grades").[a] The Arizona-grown fiber would therefore be classed with the high grades of imported Egyptian cotton.

The length of the Arizona-grown fiber was placed at slightly less than 1½ inches (average of 10 estimates)—hence superior to most grades of Mit Afifi but inferior to the best grades of Jannovitch. As to evenness or uniformity of length, all but 1 out of 11 opinions were very favorable, 2 of the experts pronouncing the Arizona product superior in this respect to imported Jannovitch.

In respect to fineness, the consensus of opinion appeared to be that the fiber is somewhat inferior to Jannovitch but superior to Mit Afifi. In regard to the strength of the Arizona-grown fiber, all the reports were satisfactory, most of the experts considering it equal to that of imported Jannovitch, while one manufacturer reported it as "rather better." The color was pronounced to be lighter than the best grades of Mit Afifi, but darker than Jannovitch. Only 1 out of the 14 experts who rendered an opinion on the color of the samples criticised it as "uneven." The luster of the Arizona-grown fiber was generally regarded as somewhat inferior to that of imported Egyptian. The "cling," or "barb," an important quality in making strong thread, was commented upon favorably by the two manufacturers who mentioned this point. Opinions differed somewhat as to the freedom of the samples from waste, the consensus being apparently that in this respect the Arizona cotton was similar to all but the best grades of imported Egyptian. As to absence of "nep," the opinions were on the whole decidedly favorable.

The manufacturers and buyers who examined the Arizona-grown fiber were practically unanimous in stating that it could be satisfactorily substituted for corresponding grades of imported Egyptian cotton.

---

[a] Prices quoted on the Boston market as given in the Commercial Bulletin of Boston, February 15, 22, and 29, and March 7, 1908.

It is evident from the reports received that the experts differed as to the variety of cotton represented by the samples, some making their comparison with Mit Afifi and some with Jannovitch. A summing up of the opinions received indicates that the Arizona cotton is exactly intermediate between these two varieties in almost every character. This is not surprising, since the samples were taken from the yield-test plats of 1907, which were grown from seed obtained from the "second-select" plants in the breeding rows of 1906 and mixed together. As has already been pointed out, the seed with which the breeding experiments were commenced at Yuma, although imported under the name of Mit Afifi, produced many plants which approximated the Jannovitch variety in the quality of their fiber. During the last two years superior plants typical of each of these varieties have been selected, and it is expected that in a short time there will be available a supply of pure seed of both Mit Afifi and Jannovitch Egyptian cottons thoroughly adapted to the climate of the Colorado River region.

TYPES PRODUCED.

To sum up, two well-marked types of Egyptian cotton, both developed from mixed seed that was imported under the name of Mit Afifi, have been carried through five generations of acclimatization and selection and have now reached a high degree of uniformity and adaptability to conditions in the southwestern United States. These are (1) the Mit Afifi type, having fiber that averages $1\frac{1}{2}$ inches in length, very strong, soft, and fine, decidedly crinkly, and of a light-brown color; (2) the Jannovitch type, with fiber averaging $1\frac{5}{8}$ inches in length, smoother, silkier, and more lustrous than the Mit Afifi, and of a very delicate cream color. The latter type may be regarded as almost intermediate in most of its characters between Mit Afifi Egyptian on the one hand and Sea Island on the other.

IRRIGATION EXPERIMENTS.

In order to determine the effect upon the yield and quality of the fiber produced by different amounts of irrigation water applied at different intervals, a series of plats was planted to Mit Afifi Egyptian cotton at Yuma in 1907.

The soil of these plats was fairly uniform, being a sandy loam on the surface with rather open sand in the subsoil. This land had not been in crop for about ten months previous to planting the cotton and had not been irrigated, so that it was very dry. It was plowed and prepared for planting early in March, 1907, was thoroughly irrigated by flooding on March 23, and the cotton was planted five days later. No facilities were at hand for measuring the amount of water applied at each irrigation, but the effort was always made to irrigate

each of the plats for about the same length of time with the same head of water. In each case the land was cultivated with either a 5-shovel or a harrow-tooth cultivator as soon as possible after irrigation, although in the case of plat 5 cultivation was not possible after the later irrigations, owing to the large size of the mature plants.

The table which follows gives the dates on which each plat was irrigated from the time the cotton was planted until the last picking was made:

TABLE VIII.—*Numbers and dates of waterings given irrigation experiment plats at Yuma in 1907.*

Dates of irrigations.	Plat 1.	Plat 2.	Plat 3.	Plat 4.	Plat 5.
May 9	X		X	X	X
May 25		X			X
July 3					X
July 15		X			X
July 25					X
August 6					X
August 24			X		X
September 12		X		X	X
Total number	1	3	2	2	8

In Table IX are given the dates of each picking on each plat, the number of pounds of seed cotton (calculated on the basis of 1 acre) secured at each picking, and the percentage of the entire yield of each plat represented by the corresponding picking and those previous to it.

TABLE IX.—*Yields of seed cotton (in pounds per acre and percentages of the total yield) secured on the irrigation experiment plats at Yuma in 1907.*[a]

Dates of pickings.	Plat 1.		Plat 2.		Plat 3.		Plat 4.		Plat 5.	
	Seed cotton.	Per cent of total.	Seed cotton.	Per cent of total.	Seed cotton.	Per cent of total.	Seed cotton.	Per cent of total.	Seed cotton.	Per cent of total.
	Lbs.		*Lbs.*		*Lbs.*		*Lbs.*		*Lbs.*	
September 19			688	20.7						
September 22							664	31.9		
September 23					470	17.6				
September 24	451	30.6								
October 9									332	12.2
October 11			567	37.7						
October 19	291	50.3								
October 22					729	44.9	448	53.4		
October 23									535	31.8
October 25			567	54.8						
October 28	402	77.6								
November 5					584	66.7			391	46.3
November 6							303	68.1		
November 12			706	76						
November 22									772	74.7
December 20	330	100			891	100	664	100	693	100
December 23			802	100						
Total	1,474		3,330		2,674		2,079		2,723	

[a] In the columns headed "Seed cotton" are given the pounds per acre obtained on each plat at each picking. In the columns headed "Per cent of total" are given the accumulated percentages of the total yield from each plat that had been secured up to the date of the respective picking.

It will also be interesting, as a measure of the degree to which ripening was hastened or retarded by the treatment given the different plats, to note the average number of large but green and still unopened bolls per plant remaining after the last picking. These were as follows: Plat 1, 0; plat 2, 4; plat 3, 21; plat 4, 25; plat 5, 23.

These plats were not planted until March 28, 1907, although if the condition of the weather alone had governed the date of planting the seed could have been put in several weeks earlier. Plat 2 was planted as a yield-test plat, but the treatment it received produced such excellent results that it is included here for comparison.

On plat 1, which was irrigated only once after planting, ripening was hastened, half of the total product having been harvested at the first two pickings. While the yield from this plat was light compared with that from the others, yet it amounted to nearly one bale per acre. The light irrigation that was given allowed the soil to remain so dry during the greater part of the summer that Bermuda grass could make little growth.

Plat 2 was irrigated three times and plats 3 and 4 twice after planting. The results from these three plats show that the longer the second irrigation was postponed the smaller was the total yield. Plat 2, which received its second irrigation six weeks earlier than plat 3 and nearly nine weeks earlier than plat 4, yielded much more heavily than the others. The first four pickings were earlier on this plat than on any of the others. It will be noted that the first irrigation was given two weeks later on plat 2 than on plats 3 and 4, which may also have had something to do with the heavier yield on plat 2. On this plat the growth induced by the irrigation on July 15, 1907, had nearly all matured when the last picking was made. The irrigation which this plat received on September 12 did not induce as much new growth as did the last irrigation given plats 3 and 4. The late growth on plats 3 and 4 did not fully mature its bolls before a frost occurred, as is indicated by the large number of green bolls remaining after the last picking was made.

Plat 5, which was irrigated eight times after planting, ripened its fiber later than any of the others, as is well shown by the fact that the percentage of the total yield represented by the first two pickings was much smaller than in the other plats, and by the high average number of unripe bolls that remained on the plants after the last picking. The first picking on this plat, although taken sixteen days later than on any of the others, yielded only 12 per cent of the total product. Notwithstanding, the total yield from this plat was second only to that from plat 2, there having been no killing frost in 1907 until the middle of December. In ordinary years cotton irrigated thus heavily would be in danger of a reduction of yield through

failure of many of the bolls to ripen before a severe frost occurs. The growth on plat 5 was very rank and picking was correspondingly difficult. The fiber from this plat was only about 70 per cent as strong as that from plats 1 and 2, which received, respectively, only one and three irrigations after planting. In other characters of the fiber no difference could be detected except that the color was slightly less pronounced on the excessively irrigated plat.

It would be unsafe to generalize concerning the results of experiments conducted during only one season, especially as the date of the first killing frost was unusually late in 1907. It may be said, however, that on sandy loam soils in the Colorado River region heavy yields of Egyptian cotton are possible with very moderate irrigation provided the soil is thoroughly cultivated after each watering and that apparently little benefit is obtained from the application of water after the 1st of September. Further experiments are necessary to determine accurately the amount of water that will produce the best results on the various types of soils occurring in the region.

SUGGESTIONS AS TO CULTURAL METHODS.

Cotton has been so little grown under irrigation in the United States that much remains to be learned about producing the crop under these conditions. The following suggestions are based partly upon the limited experience that has so far been obtained in the Southwest and partly upon our knowledge of the methods followed in Egypt. As has already been pointed out, however, the Egyptian system of growing cotton can not be closely followed in the United States, owing to the great difference in the labor conditions of the two countries.

IRRIGATION.

The principal difference between cotton culture in the arid region of the United States and in the South Atlantic and Gulf States is the almost perfect regulation of the water supply that is possible under irrigation. This enables the farmer to control the condition of the soil, so that it need never be wet at times when plowing, planting, cultivating, picking, and other cultural operations should be performed. This and the almost total absence of rain during the growing season make it much easier to plan and carry out the farm work. The expense of irrigating is more than compensated for by these advantages and by the fact that there is little danger of loss or damage from rainy weather.

In all irrigated districts where water is abundant there is a tendency to irrigate too frequently and to cultivate too little. The practice of excessive irrigation instead of cultivation is always objection-

able, as it tends to leach the soil of its plant food, injures its mechanical condition, and encourages the growth of weeds. In cotton culture it has the further disadvantage of causing an overproduction of wood and a retarded ripening of the bolls. The conservation of the soil moisture by thorough tillage after each irrigation is in every way a more economical practice.

The first essential to successful irrigation is thorough leveling of the land. For a cultivated crop like cotton a fall of 2 inches to every 600 feet is sufficient in most soils. The frequency with which irrigation should be given depends largely upon the character of the soil. Heavy loams and clays have of course a high water-holding capacity and do not need to be irrigated as often as sandy loams. On heavy land, if well tilled, one or two irrigations after planting are sufficient to mature a crop of cotton properly, while on the very light soils three to five irrigations may be required.[a]

Irrigation by flooding requires the least labor and gives the most satisfactory results. In Egypt, where an abundance of very cheap labor can be had, furrow irrigation is practiced, but in this country the cost of labor would be almost prohibitive, even if it were found otherwise desirable to adopt the furrow system. The quantity of water given cotton at any one irrigation should be sufficient to insure penetration of the soil to a considerable depth. In most cases flooding to a depth of about 6 inches suffices.

Cotton is a comparatively drought-resistant plant, which is probably at least partly due to its deep rooting habit. It has been found that in the rather light soils of the Yuma Valley, if good cultivation is given, the roots of this plant will penetrate to a depth of 6 to 8 feet. Hence, cotton requires less frequent irrigation than shallow-rooted crops. It has been observed, however, that the Egyptian varieties show the effect of drought sooner than Upland cottons.

Since the amount of water that will produce the best results and the frequency with which irrigations should be given depend largely upon the character of the soil and the thoroughness of the tillage, it is difficult to give precise directions on these points. In general, cotton should be irrigated as little as possible after it has begun flowering. Heavy irrigation in the latter part of the summer, especially during very dry, hot weather, results in a dropping of the squares[b]

[a] In Egypt, as has already been noted, 10 irrigations are ordinarily given between the date of planting and that of the first picking. It must be remembered, however, that as cotton is planted in Egypt there are 10 times as many plants to the acre as in the experiments at Yuma. If closer planting is practiced in the Southwest, more water will probably be required.

[b] The term "square" is applied to the unopened bud of the cotton flower with its inclosing bracts.

and young bolls. It is also likely to stimulate a late growth, so that there is danger that many bolls will be caught by frost before reaching maturity.

PREPARATION OF THE LAND.

Thorough preparation of the soil is necessary to insure perfect germination. If no winter or green-manure crops are grown on the land it should be plowed in the fall, so as to expose the greatest possible amount of surface to the air during the winter months. Plowing to a depth of 6 to 10 inches is advisable in all types of soil, as it encourages the development of a deep root system. The work should be done when the surface soil is not dry and baked, otherwise difficulty will be experienced in obtaining a mellow, well-pulverized seed bed.

If a winter crop is grown it should be removed and the ground plowed as early in the spring as possible. It is essential to turn under green-manure crops several weeks before planting cotton, in order that they may decompose somewhat before the seed is put in. Just before giving the first irrigation in the spring the land should be well harrowed and gone over once with a leveling drag, in order to remove the inequalities caused by plowing. In the latter part of February or early in March the land should be thoroughly flooded, so that every part of it is covered to a depth of 3 or 4 inches. Unless this is done germination will not be uniform and the stand will be imperfect. As soon after this first irrigation as possible the land should be double-disked and then worked over with a smoothing harrow. On some soils it may be necessary to follow the smoothing harrow with the leveling drag. These operations, if carried out at the proper time, will insure a loose, mellow, and moist seed bed over the entire field. Under these conditions, if good seed is used, germination will take place in five or six days and a uniform stand will be obtained.

PLANTING.

In the Southwest cotton should be planted early. Without exception the plantings made at Yuma between March 15 and March 30 gave larger returns than later plantings of the same varieties. Seed that was put in early produced plants that branched well near the ground and made a more determinate growth than those that came from seed planted near the end of April. The latter came up readily and grew rapidly, but the plants were spindling, the yield light, and the crop late in maturing. Periods of cold weather are likely to follow early planting and to retard the upward growth of the young plants, but during these periods a good root system is being developed and when warm weather comes on later such plants make a more satisfactory growth than those from later plantings. Of course, the

proper time for planting in any locality will depend largely upon the normal date of the last frost in the spring. Cotton seed should be put in as soon as the danger of killing frost is past. In the Colorado River region it is probable that in ordinary seasons planting can be done to advantage between March 1 and March 15, and in the Salt and Gila valleys between March 15 and March 31.

The proper distance for planting Egyptian cotton in the Southwest varies somewhat according to the nature of the soil, but it is always much greater than that used in Egypt for the same varieties or in the southern United States for Upland varieties. Experiments in the South indicate that the yield increases as the space assigned to each plant approaches a perfect square. Egyptian varieties, however, grow more rankly and require more space than any Upland variety. Moreover the weight of the bolls at the ends of the long branches bears them almost to the ground and makes the last cultural operations and the picking so difficult that it is advisable to have the rows much farther apart than the hills. A distance of 6 feet between the rows, with the plants 3 feet apart in the row, which gives each plant 18 square feet, produced very satisfactory results at Yuma during the past season. A yield at the rate of 990 pounds of fiber per acre was obtained from the Mit Afifi variety planted at this distance, which requires only 5 or 6 pounds of seed per acre. It is possible that very close planting in the row may tend to check the luxuriance of growth of this type of cotton without decreasing the yield.

As the acclimatization of Egyptian cotton progresses, the proper planting distance can doubtless be very materially decreased. The average distance in Egypt for the same varieties of cotton is 32 inches between the rows, with the hills 16 inches apart in the row and with two plants to the hill. These distances allow each plant 1.8 square feet of ground space, or just one-tenth that given at Yuma. With this planting distance there would be 24,000 plants per acre or ten times the number present when the distance is that adopted last year at Yuma. The average amount of seed used per acre in Egypt is 45 pounds. The great difference between the planting distance generally used in Egypt and that which has so far given the best results at Yuma indicates that much allowance must be made for the effect of further acclimatization in reducing the size of the plants. Moreover, additional experiments are necessary in order to determine the most profitable planting distance for Egyptian cotton on different types of soil in the Southwest.[a]

[a] It is proposed to test different planting distances at Yuma during the season of 1908.

If the soil has been well prepared and is free from Bermuda grass, the ordinary one-horse cotton drill is the best implement for planting; otherwise, hand planting must be resorted to in order that the seed may be placed in moist soil.

The proper depth depends upon the character of the soil and the date of planting. The earlier the seed is put in, the shallower should be the depth. If cold weather follows deep early planting, the seed is likely to rot in the ground, or if germination takes place the seedlings will not have sufficient vitality to force their way through the soil. In Egypt the approved depth is 2 or 3 inches. At Yuma, however, although the soils are lighter than most Egyptian cotton soils and planting has heretofore been done at a later date than is usually the case in Egypt, a depth of only 1½ inches gave excellent results, the seed having germinated readily and the plants having become well established in a very short time.

The cotton plant, when once established, will survive rather adverse climatic conditions, but during the first two weeks after germination it is sensitive to excessive moisture, heat, and cold. The seedlings of Egyptian cotton, however, are hardier than those of Upland cotton and recover more quickly from the effects of cold weather. Dry planting followed by a flooding, which is a frequent procedure in growing grain under irrigation, should never be practiced with cotton. The water packs the soil so firmly about the seed that a poor stand is sure to result. Very little moisture is required to germinate cotton seed provided the soil is lightly firmed about the seed at the time of planting.

When the cotton drill is used in planting, the seed should be dropped about 6 inches apart in the row if the plants are afterwards to be thinned to a distance of 3 feet. If the distance after thinning is to be less than 3 feet, the seeds should be dropped correspondingly closer. When the plants are 6 inches high, or soon after the third leaf appears, they should be "chopped" out to the desired distance with a hoe. If hand planting is practiced, care must be taken in thinning the hills to avoid injury to the plants that are left standing. The difficulty in doing this satisfactorily is one of the principal objections to planting in hills.

In selecting seed for planting only ripe, heavy seed that shows a high percentage of germination[a] should be chosen. Egyptian cotton seed that has been grown in the Southwest for several years is in every way preferable for planting to seed newly imported from Egypt, as it is better adapted to the changed climatic conditions. Plants from

[a] A convenient method for testing the viability of cotton or other seeds is to place 100 seeds between two pieces of moist cotton cloth and inclose the cloth and seed between two plates. The number of seeds that germinate constitutes the percentage of viability.

such seed have a more determinate growth, yield better, and their bolls open more satisfactorily than those from unacclimated seed.

CULTIVATING.

If the ground has been well irrigated and then thoroughly pulverized previous to planting, the plants will reach a height of 8 to 10 inches before a second irrigation is required. Withholding water for some time after planting encourages the development of a deep root system. On the other hand, frequent irrigation at this time encourages the growth of lateral roots close to the surface of the soil, which is undesirable, as plants possessing a root development of this character are the first to suffer in case there is a shortage of water later in the season. Thorough cultivation, so as to establish a dust mulch 2 or 3 inches deep, should follow every irrigation just as soon as the soil is dry enough to be tilled. Conservation of soil moisture by cultivation is cheaper and more satisfactory than frequent irrigation.

On light soils a 14-harrow-tooth cultivator is the best implement to use in forming a dust mulch. On heavy soils a five or seven shoveled cultivator with a pulverizing attachment, followed by the harrow-toothed cultivator, will produce the same results. It is advisable to use the scuffle-hoe attachment for the five-shoveled cultivator in case the field is weedy. If the land is free from weeds, the only hand work necessary will be that required in thinning out the plants and loosening the soil around them after the first irrigation, while they are small and tender. The experience so far obtained at Yuma would indicate that cultivation should cease soon after the plants begin blossoming.

PICKING.

In localities where frost occurs early in the fall, the growing period can be shortened by giving the last irrigation at a correspondingly early date. If this is done, the plants will set their bolls and mature their crop much earlier than when an abundance of water is given throughout the growing season. In localities where the season is comparatively short and it is consequently necessary to restrict the growing period of cotton, closer planting is also to be recommended.

If the cultural methods above described are followed, cotton planted in the Colorado River region in the middle of March should be ready for the first picking by the middle of September. Egyptian cotton has a less determinate growth than the Upland varieties and matures its crop during a longer period and at a lower temperature than the latter. This necessitates a larger number of pickings than for most Upland varieties. The comparatively rank growth of the Egyptian varieties, making work between the rows more difficult, their habit

of bearing the bolls at the ends of the branches, thus bending the latter to the ground, and the smaller size of the bolls make picking slower and hence more expensive than with Upland varieties. It is probably safe to estimate that the average cotton picker can gather Egyptian cotton about two-thirds as rapidly as Upland.[a]

In 1907, when the first killing frost did not occur until after the middle of December, four and on some plats even five pickings of Egyptian cotton were made at Yuma. But if the crop is grown on a commercial scale, it is probable that, as in Egypt, only three, or at most four, pickings will ordinarily be made. It is, however, especially important with Egyptian varieties not to leave the cotton unpicked for any considerable length of time after the bolls open, as exposure to the weather damages the fiber. In picking, great care should be taken to keep the cotton as free as possible from fragments of leaves, flowers, bolls, etc. In grading Egyptian cotton much importance is attached to its freedom from "trash," and the price obtained largely depends upon the cleanness of the fiber.

No very satisfactory and economical method has yet been found for removing the stalks that remain in the field after the last picking. The vigorous growth of Egyptian cotton plants makes the methods used with Upland cottons in the South impracticable. Probably as good a way as any is to cut out the plants by hand and throw them into piles; one man can do this work at the rate of an acre a day. Until some economical use is found for the stalks, they can best be disposed of by burning them in the field as soon as they are dry. If there are many immature bolls and green leaves remaining after the last picking, the field can be profitably pastured by dairy stock or beef cattle.

MACHINERY REQUIRED.

No expensive field machinery is necessary in Egyptian cotton culture. When the land has once been leveled, the only implements needed by the individual farmer are an ordinary two-horse walking plow or disk plow, a smoothing harrow, a homemade leveling drag, a two or four horse disk harrow, and a one-horse cotton drill. With the exception of the last, all of these implements are to be found on the average irrigated farm.

In order to prepare the product for the market, more costly machinery, i. e., gins for separating the fiber and presses for baling it, will be required. These can be more advantageously purchased and operated by a cooperative association of cotton growers than

[a] Mr. Robert Viewig, who grew Egyptian cotton at Godwinsville, Ga., in 1900, reported to Mr. L. H. Dewey, of the Bureau of Plant Industry, that the negroes in his vicinity preferred to pick Egyptian cotton at the rate of 75 cents a hundred pounds to Upland cotton at 50 cents a hundred pounds.

by individual farmers. The long fiber of Egyptian cotton can not be separated without injury by the saw gins used for short-staple Upland cottons. Roller gins, such as are used in Egypt and in the Sea Island district in South Carolina and Georgia, will be necessary. A good roller gin, capable of turning out 60 to 100 pounds of fiber an hour, costs at the factory about $150.[a] It will be found more economical to set up a battery of from four to eight gins than to install power to run a single gin. As a rule, in Egypt much greater care is used in ginning than in the United States, and the fiber as it reaches the manufacturer is much cleaner and more attractive looking. If this type of cotton is grown in the southwestern United States, the chances of marketing it advantageously will be much increased by careful ginning.

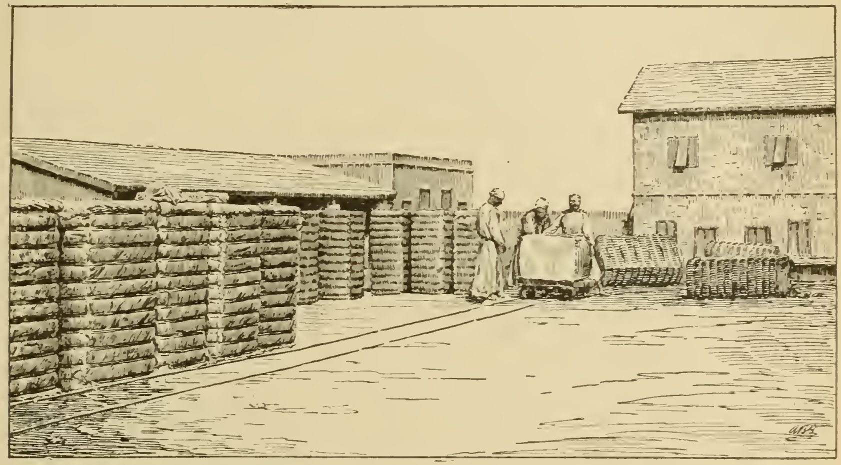


Fig. 2.—Finished Egyptian cotton bales at a ginnery at Kafr ez Zayat, Egypt.

A single-box screw press having an hourly capacity of 1½ bales (hence about the capacity of 10 roller gins) can be purchased at the factory for $160. A revolving double-box press with an hourly capacity of 4 to 5 bales costs from $300 to $500 at the factory. These presses will turn out ordinary rough bales in sufficiently good shape for shipment to one of the southern cities where compresses are operated. At the outset, presses of this description would probably answer the purpose of southwestern cotton growers.

We must not, however, lose sight of the fact that buyers and manufacturers of Egyptian cotton are accustomed to receiving it in the very compact, well-made bales shown in text figure 2. The care with

[a]Another roller gin that is much used in the Sea Island district is stated to have a capacity of 1½ bales daily. While the saw gin does much more rapid work than the roller gin, it would be almost impossible to market long-staple fiber if ginned on the former machine.

which it is put up has contributed not a little to enhance the reputation of this type of cotton. Almost without exception American users of Egyptian cotton have mentioned the care with which it is ginned and baled as one of their chief reasons for preferring it. If Egyptian cotton culture were to be undertaken on a commercial scale in the Southwest, growers in that section would obtain a great advantage by securing, from the outset, a reputation for care in putting up their product equal to that enjoyed by the Egyptians. To accomplish this a compress will be needed in order to make the bales turned out by the gin presses still more compact. If a compress were located in the region where the cotton is grown, so that the much less bulky compressed bales could be shipped from the point of production, a considerable saving in freight rates would doubtless result. In view of the long haul to a seaport that will be necessary, this is a very important consideration and should not be overlooked by those who may contemplate growing cotton in the Colorado River region.

The compresses ordinarily seen in the cotton belt are large establishments located at important shipping centers and costing $35,000 to $50,000. There is, however, a compress manufactured in the United States that costs only $3,800, delivered on the cars at the factory. It is calculated that set up at any point on the railway in southern Arizona or southeastern California it would cost not more than $5,500. This compress is advertised as turning out a bale which is 55 by 21 by 20 to 26 inches in dimensions [a] and which weighs approximately 500 pounds. The daily capacity is said to be from 100 to 125 bales (in a twenty-four-hour day). Such a compress should be able to handle all the cotton produced in a large community. The decreased bulk of the bales, which would result in a saving of freight rates, and their attractive appearance, which would facilitate sales to buyers and manufacturers of this type of cotton, should be ample warrant for installing such a compress in any community where Egyptian cotton growing is seriously undertaken.

ROTATIONS.

The alluvial soils of the Salt, Yuma, and Imperial valleys are for the most part well supplied with all the mineral elements necessary for plant growth, but are often deficient in humus or organic matter, which is essential in maintaining a proper physical condition. Furthermore, cotton, if planted continuously on any soil, will gradually deplete its fertility, being especially exhaustive of nitrogen. In order, therefore, to maintain a sufficient nitrogen content and to in-

[a] This bale would therefore be about as bulky in proportion to the weight of its contents as the Egyptian and about two-thirds as bulky as the ordinary American compressed bale.

crease the supply of humus, leguminous crops should be grown in rotation. For a long-period rotation there is nothing better than alfalfa. But if it is desired to grow cotton at frequent intervals on the same land, winter annual or green manure crops must be introduced. Berseem (Alexandrian clover) is extensively used for this purpose in Egypt, and experience indicates that it will do well as a winter crop under irrigation in the Colorado River region. The productiveness of this clover and the great number of nitrogen-bearing nodules that develop on its roots make it an excellent plant to use in rotation with cotton and with cultivated summer crops in general. Other leguminous plants, some of which will probably prove valuable as soiling or green-manure crops, are being tested in the region. If a proper rotation system is adopted at the outset, commercial fertilizers will probably not be required in this region for many years in connection with cotton raising.

LABOR CONDITIONS.

The greatest obstacle to cotton culture in the Southwest at present is the difficulty of procuring labor for picking. In this connection it may be stated that picking is the only cultural operation that costs more for Egyptian than for Upland cotton. The cost of preparing the land, planting, irrigating, and cultivating is the same for both kinds. Hence, the total expense to the acre in producing Egyptian cotton is very little more than in producing Upland cotton.

The labor conditions in the Colorado River region are unusual, owing to its remoteness from labor centers. Ordinary farm labor often commands $2 a day or $1.50 with board. Cotton picking, however, can be satisfactorily performed by the cheapest class of labor. Under certain conditions some of the agriculturally inclined Indians might make very good pickers. In the event of cotton culture being developed on a commercial scale, Indian families could probably be employed to do the picking at a reasonable cost. If the industry becomes established in this region, the cost of picking will probably be reduced in proportion as the population becomes denser and the pickers more adept.

It is believed, however, that the best chance of establishing a cotton industry in the Colorado River region is not on the basis of a large individual acreage, requiring much hired labor, but on the basis of 2 to 5 acres to each farm, the farmer's family supplying most of the labor needed. A total acreage large enough to warrant the establishment of a compress could thus be secured. The comparatively small size of the farm units on the Salt River and Yuma reclamation projects will favor this distribution of the cotton acre-

age among many small growers. On this basis Egyptian cotton may reasonably be expected to become one of the staple crops in the irrigated districts of the hot Southwest.

MARKETS AND TRANSPORTATION.

The Colorado River region is a long way from the manufacturing centers where Egyptian cotton is chiefly used. In the United States these are mostly situated in New England. To market the product to the greatest advantage it will probably be necessary to ship it either to Boston or to Liverpool, the latter city being the greatest market in the world for Egyptian cotton. This will necessitate transportation by railway either to Galveston, Tex., the nearest port on the Gulf of Mexico, or else to some Pacific coast port, whence shipment could be made around Cape Horn. The former route would require a longer haul by railway, but a very much shorter transit by water to ports that are near the manufacturing centers. The latter route will very likely become the cheaper one when the Panama Canal is completed.

There is reason to hope that ultimately there will be a market on the Pacific coast for all cotton grown in Arizona and California. A mill which it is said now obtains from Texas 12,000 bales of cotton annually has been in operation in California for twenty years. Only short-staple cotton is utilized by this factory, but the existence near the Pacific coast of a source of supply of more valuable fiber might encourage the erection of factories adapted for the manufacture of the best grades of cotton goods.

The seed is a by-product of immense value in connection with cotton growing. There would probably be a good local market among dairymen and feeders for most of the cotton seed produced in the Colorado River region, since the price of all feed stuffs is very high there. Oil mills would probably soon spring up on the Pacific coast and would afford a market for any surplus that might exist.

DISEASES AND INSECT ENEMIES.

DISEASES.

The cotton plant is susceptible to a number of diseases caused by fungi and bacteria, the most serious of which in the United States are root-rot, anthracnose or boll-rot, wilt, and the disease which is sometimes known as "black arm." The last is a bacterial disease to which the Egyptian varieties are peculiarly sensitive. The other maladies are due to the attacks of fungi. Boll-rot, or anthracnose, and "black arm" are very apt to be disseminated with seed from in-

fected areas, and it is probable that the wilt disease also can thus be conveyed. In obtaining cotton seed from the Southern States, therefore, great care should be taken to ascertain that the district from which it comes is free from all these diseases.

None of these diseases has as yet appeared as a foe to cotton in the irrigated districts of the Colorado River region, although there is every reason to fear that the root-rot, a disease peculiar to the Southwest, which is more or less prevalent on alfalfa in the Salt River Valley, may also attack the cotton plant. The only preventive measure that can at present be recommended is to avoid planting cotton on land on which alfalfa has died out in a manner suggesting the presence of root-rot. Since this fungus apparently exists in virgin land in the Southwest, sometimes attacking the first crop grown after such land is broken, it will be advisable to give all soil on which cotton is to be planted thorough aeration by means of a deep fall plowing.

THE BOLL WEEVIL.

Of the insects that attack cotton in the United States, the most injurious are the Mexican boll weevil and the bollworm. The weevil is especially to be dreaded in the Southwest. This scourge of cotton culture was first introduced into Texas from Mexico in 1893. It has spread so rapidly that in 1907 the infested area not only included the greater part of Texas and Louisiana, but had extended into Arkansas, Mississippi, and Oklahoma. There is no small danger that the entire cotton belt of the South will ultimately become infested with this insect. The direct loss due to the depredations of the weevil during the season of 1907 is estimated at 385,000 bales, valued at $25,000,000. There is no question that the weevil can be distributed with the seed. For this reason, cotton seed should under no circumstances be introduced into Arizona or California from the weevil-infested regions of the South unless it has been fumigated under proper supervision.

Owing to the danger of introducing not only the weevil but the bacterial and fungous diseases already described, the safest plan will be to import no seed from any section of the South without thoroughly fumigating it upon arrival.

BERMUDA GRASS IN RELATION TO COTTON CULTURE.

Bermuda grass has gained a substantial foothold in the valley of the Colorado River just below Yuma, and conditions there have proved so favorable to its growth that it has become a most serious pest. This is one of the few regions in the United States where this grass produces seed, and it has been found to seed freely there throughout the summer, from May to November.

Since the plant quickly takes possession of ditch banks, where it makes a luxuriant growth, the seeds spread rapidly in the irrigation water and the weed soon gains a foothold on all irrigated land. Having once gained such a foothold, the grass spreads rapidly, and unless vigorous methods are used it soon completely infests the land. On the heavier soils it seems to resist successfully all attempts to eradicate it as long as the land is irrigated. In fact, no cases are yet known at Yuma where heavy land once infested has been entirely reclaimed from it.

Where water is supplied through infested ditches, the utmost vigilance is required to keep the weed in subjection. In view of the fact that cotton requires but little irrigation and permits thorough cultivation, this crop is admirably adapted for use where Bermuda grass infestation is likely to occur, and also where it is proposed to attempt the eradication of the weed.

It seems probable that fair success in eradication might be hoped for if an infested field were pastured down very close during one summer, plowed in the autumn, allowed to lie dry for eighteen months, with an occasional cultivation during the intermediate summer to kill any plants that might start growth, and then planted to cotton the third season. One thorough irrigation in March just before planting and another early in May would be enough to mature the cotton crop, and if these irrigations were followed by thorough and persistent cultivation the growth of Bermuda grass would at least be seriously checked, and such treatment might be sufficient to kill out the plants completely.

It has been noted that a very fair crop of cotton, amounting to nearly one bale to the acre, was produced at Yuma with but two irrigations, one on March 23 and one on May 9, on land that had not been irrigated for nearly a year before the cotton was planted, and which was therefore very thoroughly dried out.

Unless some comparatively drought-resistant crop, such as cotton, can be grown on these Bermuda-grass-infested soils, it will be hopeless to try to reclaim them without keeping them dry and well cultivated for at least two years.

SUMMARY.

During the past ten years the United States has imported on the average 53,000,000 pounds of Egyptian cotton annually. In 1907 the direct imports from Egypt were valued at $16,000,000, and the average price per pound paid in Boston for Egyptian cotton was about 22 cents.

Egyptian cotton resembles Sea Island in many respects, the fiber being long, very strong, and very fine and silky. That of the leading

variety, Mit Afifi, is characterized by its brown color. Egyptian cotton is in demand for manufacturing high-grade goods of various kinds and is especially suitable for mercerizing and for mixing with silk.

The Bureau of Plant Industry has for several years experimented with Egyptian cotton at various localities in the southern United States, from South Carolina to central Texas. The results in the main cotton belt do not promise much success, the failure of many of the bolls to ripen before the first killing frost in the autumn making it impossible to obtain the maximum yields.

The Colorado River region in southern Arizona and southeastern California, which is the part of the United States that most nearly resembles Egypt in its long, hot, nearly rainless summers and its agriculture under irrigation, has proved to be well adapted to Egyptian varieties of cotton.

Experiments carried on in the Southwest, especially at Yuma, Ariz., during the last five years, have demonstrated that good yields of high-grade Egyptian cotton can be produced in that region.

Acclimatization has, however, been found necessary, since during the first two or three years of the experiments the plants made an excessive growth of wood and produced relatively few bolls, which ripened late and did not open satisfactorily.

During the past two seasons the size of the plants has diminished, the average number of bolls on each plant has greatly increased, they have ripened much earlier, and they have opened wide, rendering picking much easier.

Careful selection has also been necessary, especially with the principal variety, the Mit Afifi, which, when first introduced into the United States, was found to be much mixed, containing a large percentage of inferior individuals. The average length of the fiber was less than 1⅜ inches, and it lacked the strength, fineness, and uniform light-brown color that characterize the best grades grown in Egypt.

In 1907 the average length of fiber in the experimental field at Yuma was practically 1½ inches, and the strength, fineness, luster, and color were very satisfactory.

The selections include two well-marked types, corresponding to the two leading Egyptian varieties, Mit Afifi and Jannovitch. The first has fiber about 1½ inches in length, crinkly but fine, and of a pronounced brown color. The second, which more nearly approaches Sea Island varieties, averages 1⅝ inches in the length of its fiber, which is silky, lustrous, and of a very light cream color.

Mit Afifi Egyptian cotton yielded at Yuma in 1907 at the rate of 3,300 pounds of seed cotton to the acre. The percentage of lint being about 30, this gives a yield of two American bales, which practically equalled that of any Upland variety grown in the same field.

This yield was obtained with the rows 6 feet apart and the plants 3 feet apart in the rows, while in Egypt the rows average 32 inches apart and the hills 16 inches apart, with two plants in each hill. Hence, in Egypt there are ordinarily ten times as many plants to the acre as in the experiments at Yuma. As acclimatization in the Southwest progresses, the plants will probably become smaller and the distance for planting can be decreased.

Early planting gives much better results than later planting. The seed should be put in as soon as there is reasonable certainty of no further danger from killing frosts.

A level seed bed, with flood irrigation, is probably better adapted to conditions in the southwestern United States than the furrow method of planting and irrigating that is practiced in Egypt.

Cotton is a relatively drought-resistant plant by virtue of its deep taproot, which in the loamy soils of Yuma Valley penetrates from 6 to 8 feet. Consequently, it requires less water than most crops that are grown under irrigation.

Preliminary experiments indicate that even in a rather light loam soil two irrigations after planting suffice to produce a good crop of cotton, provided a thorough cultivation is given after each watering and a good dust mulch is at all times maintained. Irrigation is apparently unnecessary after the first of September. Heavy irrigations late in the season retard ripening and increase the risk of loss from early frosts.

The high fall temperatures of the Colorado River region and the indeterminate growth of Egyptian cotton plants cause the ripening of the fiber to be continued during several months. Three or four pickings are necessary to harvest the bulk of the crop.

The small size of the bolls of Egyptian varieties and the vigorous growth of the plants make picking slower than with large-bolled Upland varieties. To gather 100 pounds of Egyptian seed cotton requires one and one-half times as long as to gather the same quantity from big-bolled Upland varieties.

The greater cost of picking is relatively unimportant, however, in view of the much higher price brought by Egyptian cotton. That of the grade grown at Yuma in 1907 should be worth more than 1½ times as much as Middling Upland cotton. The expense of all other cultural processes is the same for both types of cotton.

At least 600,000 acres of land will be under irrigation in the Colorado River region within a few years. One-fifth of this acreage, with a yield of one American bale to the acre, could produce the average amount of Egyptian cotton that has been imported into the United States during the last ten years.

PLATES.

128

63

DESCRIPTION OF PLATES.

PLATE I. *Frontispiece.* General view of the experimental field of Egyptian and other varieties of cotton at Yuma, Ariz., in 1907. The breeding rows are shown in the foreground. Plats were also grown for yield tests and for experiments with different times and frequency of irrigation. The rows were 6 feet apart and the plants 3 feet apart in the rows in this field.

PLATE II. Fig. 1.—A plant of Egyptian cotton at Yuma in 1903, grown from seed produced by plants grown the year previous from imported seed. The illustration shows the undesirable shape and rank growth of the unacclimatized plants (the shaft of the auger being $3\frac{1}{2}$ feet long); also the comparatively small number of bolls produced. Fig. 2.—Mit Afifi Egyptian cotton at Yuma in 1907, showing the productiveness and satisfactory opening of the bolls brought about by six years of acclimatization and selection. The ripe cotton hangs loose in the fully open bolls, making picking much easier than was the case during the first three years after introduction into the Southwest, when the bolls opened only partially and the cotton had to be pulled out between the points of the valves.

PLATE III. Representative plants of Mit Afifi Egyptian cotton at Yuma in 1907, showing the greatly reduced size and improved shape as compared with the plant shown in Plate II, figure 1. The plant with a branch nearly as long as the main stem, shown in the upper figure, is the more typical one. The perfect manner in which the bolls opened in 1907 is well shown in the lower figure.

PLATE IV. Open (*b*, *c*) and unopened (*c*, *d*) bolls and detached involucral bract (*a*) of Mit Afifi cotton at Yuma in 1907, natural size. The illustration shows the small, pointed, 3-locked bolls characteristic of the Egyptian type of cotton. The open bolls are seen both from above (*b*) and from the side (*c*).

PLATE V. Combed-out seed cotton (natural size) of one of the individual selections of Mit Afifi cotton grown at Yuma, Ariz., showing increased length due to five generations of selection. A is the original selection, grown in 1903 from seed produced the year before from imported seed, and is the progenitor of B, which was produced in 1907. Owing to the curling of the fibers after combing, the full length, which was $1\frac{3}{8}$ inches in A and $1\frac{5}{8}$ inches in B, is not shown. The illustration represents the average difference in length between the forty individual selections made in 1907 and their progenitors in 1903.

FIG. 1.—EGYPTIAN COTTON PLANTS AT YUMA, ARIZ., IN 1903, SHOWING RANK GROWTH AND RELATIVE STERILITY.

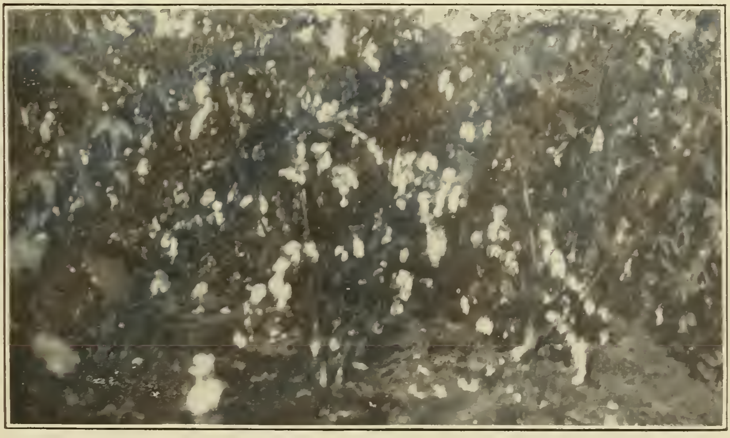
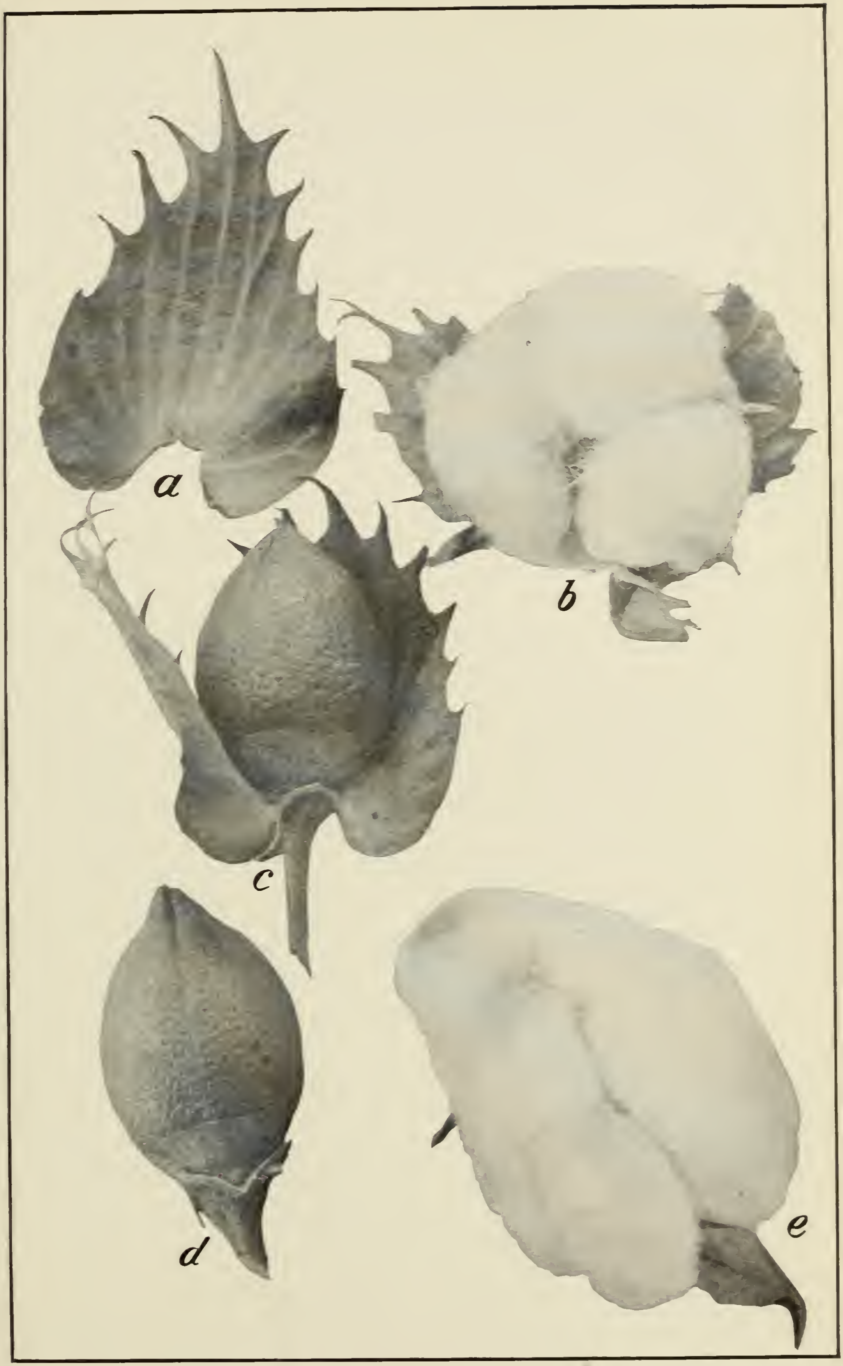


FIG. 2.—EGYPTIAN COTTON PLANTS AT YUMA IN 1907, SHOWING PRODUCTIVENESS AND SATISFACTORY OPENING OF BOLLS.

FIG. 1.—TYPICAL MIT AFIFI COTTON PLANT GROWN AT YUMA, ARIZ., IN 1907.

FIG. 2.—ANOTHER TYPICAL MIT AFIFI COTTON PLANT GROWN AT YUMA IN 1907.



OPEN AND UNOPENED BOLLS OF MIT AFIFI COTTON GROWN AT YUMA, ARIZ., IN 1907.

(Natural size.)

MIT AFIFI SEED COTTON, SHOWING IMPROVEMENT BY SELECTION: A, SELECTION OF 1903; B, DESCENDANT IN 1907.

(Natural size.)

INDEX.

O